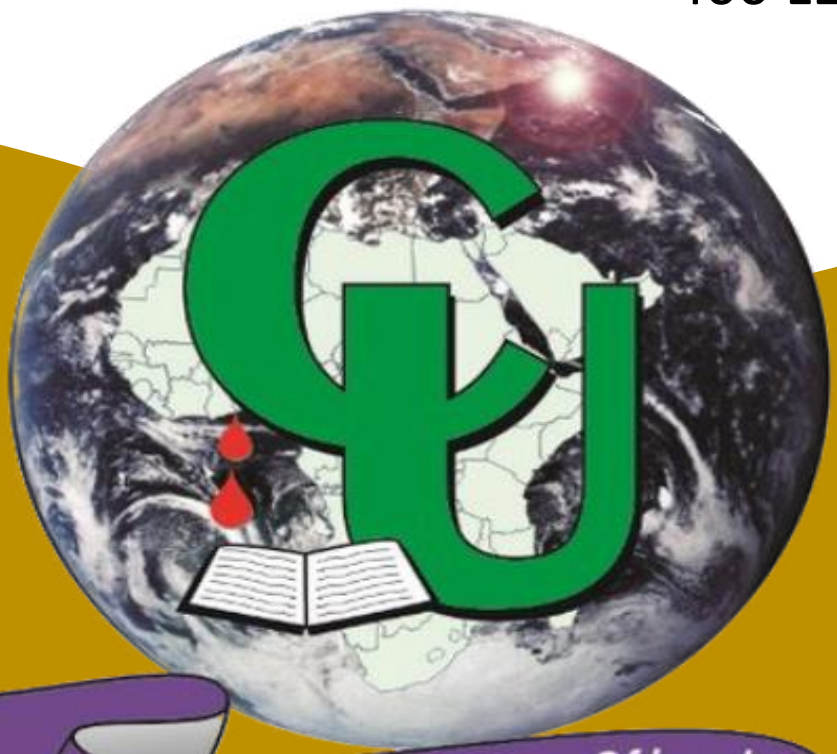
COVENANT UNIVERSITY

ALPHA SEMESTER TUTORIAL KIT
(VOL. 2)

PROGRAMME:CIS
400 LEVEL



DISCLAIMER

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LIST OF COURSES

CSC411: Software Engineering
CSC413: Algorithm & Complexity Analysis
CSC415: Artificial Intelligence
CSC431: Computational Science & Numerical Methods I
CSC432: File Processing
CSC433: Computer Graphics and Animation
MIS412: Knowledge Management
MIS415: Project Management

COVENANT UNIVERSITY

CANAANLAND, KM 10, IDIROKO ROAD
P.M.B 1023, OTA, OGUN STATE, NIGERIA.

TITLE OF EXAMINATION: B.Sc EXAMINATION
COLLEGE: Science and Technology
DEPARTMENT: Computer and Information Sciences
SESSION: 2015/2016 **SEMESTER:** ALPHA
COURSE CODE: CSC411 **UNIT:** 3
COURSE TITLE: SOFTWARE ENGINERRING
INSTRUCTION: Answer Question 1 and any other Three (3) questions **TIME:** 3Hhrs

1a i)Define the following: i) Software Engineering ii) Software Product iii) Software Process

iv) Software Engineering Methods
[6mks]

ii). What are the differences between generic software product development and custom software development?
[2mks]

b. Draw a context model for a patient information system in a hospital. You may make any reasonable assumptions about the other hospital systems that are available, but your model must include a patient admissions system and an image storage system for X-rays, as well as other diagnostic records [5mks]

c). Based on your experience with a bank ATM, draw a data-flow diagram modelling the data processing involved when a customer withdraws cash from the machine.
[7mks]

d). Use the Testing Scenario below to generate at least five (5) Test Cases for a System Test on Project Management System (PMS).

A final year student in CIS department is working on a project. The student is stock and needs to get copies of previous projects related to his work. CIS department has a system called PMS that manages previous projects. He logs on to the system and is able to use the search facility of PMS to find e-copies of related projects. He is allowed to download only three copies per day. If he needs more then he uses a module in PMS that request for permission and registers his request. If granted he has privilege to download only two more for that day. [5mks]

2a. Develop a sequence diagram showing the interactions involved when a student registers for a course in a university.

Courses may have limited enrolment, so the registration process must include checks that places are available.

Assume that the student accesses an electronic course catalogue to find out about available courses. [5mks]

b.i) Discuss the major challenges facing Software Engineering.
[6mks]

ii) State the differences between the following: i) User Requirement and System Requirements

ii) Functional and Non-functional Requirements
[4mks]

3a. Discuss the following software development process models. Include appropriate diagrams.

i)Waterfall Model ii) Spiral Model
[10mks]

b. Suggest who might be stakeholders in a university student records system. Explain why it is almost
inevitable that the requirements of different stakeholders will conflict in some way.

4a i)Explain why the rapid delivery and deployment of news systems is often more important to businesses than detailed functionality of these systems.
[3mks]

ii)When is it appropriate not to recommend agile method for developing a software system?
[3mks]

b i)Suggest four (4) reasons why the productivity rate of programmers working as a pair is roughly the same as two programmers working individually.
[4mks]

ii)Extreme programming expresses user requirements as stories, with each story written on a card. Discuss the advantages and disadvantages of this approach to requirements description.
[5mks]

5ai) Discuss the differences between verification and validation, and explain why validation is a particularly difficult

process.
[4mks]

ii) Explain why it is not necessary for a program to be completely free of defects before it is delivered to its customers.

To what extent can testing be used to validate that the program is fit for its purpose?
[6mks]

b) Explain why program inspections are an effective technique for discovering errors in a program.
[5mks]

6a. Explain the Software Testing Process. Include the appropriate diagram
[6mks]

bi) Differentiate between White Box and Black Box Testing
[5mks]

ii) Explain why interface testing is necessary even when individual components have been extensively validated
through component testing and program inspections.
[4mks]

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COLLEGE: Science and Technology
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SESSION: 2015/2016 **SEMESTER:** ALPHA
COURSE CODE: CSC411 **UNIT:** 3
COURSE TITLE: SOFTWARE ENGINERRING

Marking Guide

1a i)Define the following: i) Software Engineering ii) Software Product iii) Software Process iv) Software Engineering Methods
[6mks]

i) Software engineering is an engineering discipline that is concerned with all aspects of software production
from the early stages of system specification to maintaining the system after it has gone into use. [1 ½ mks]

ii) Software Products - Computer programs and associated documentation. Software products may be developed for a particular customer or may be developed for a general market [1 ½ mks]

iii) Software Process - is the set of activities and associated results that produce a software product. There are four fundamental process activities that are common to all software processes. These are:

- *Software specification* where customers and engineers define the software to be produced and the constraints on its operation.
- *Software development* where the software is designed and programmed.
- *Software validation* where the software is checked to ensure that it is what the customer requires.
- *Software evolution* where the software is modified to adapt it to changing customer and market requirements.

[1 ½ mks]

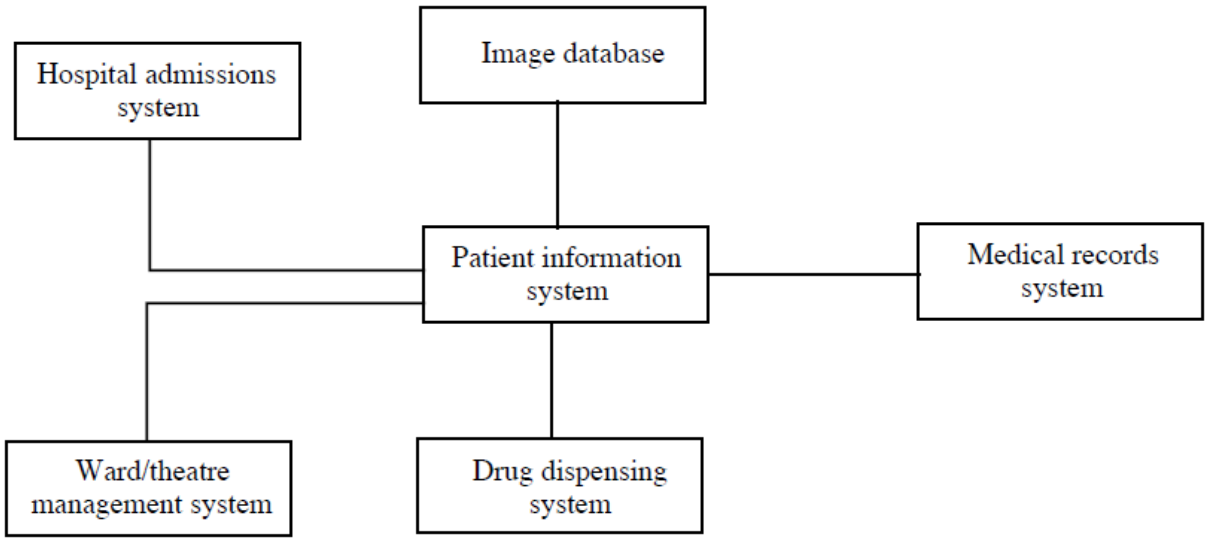
iv) Software Engineering Methods - A software engineering method is a structured approach to software development whose aim is to facilitate the production of high-quality software in a cost-

effective way
[1 ½ mks]

ii). What are the differences between generic software product development and custom software development?

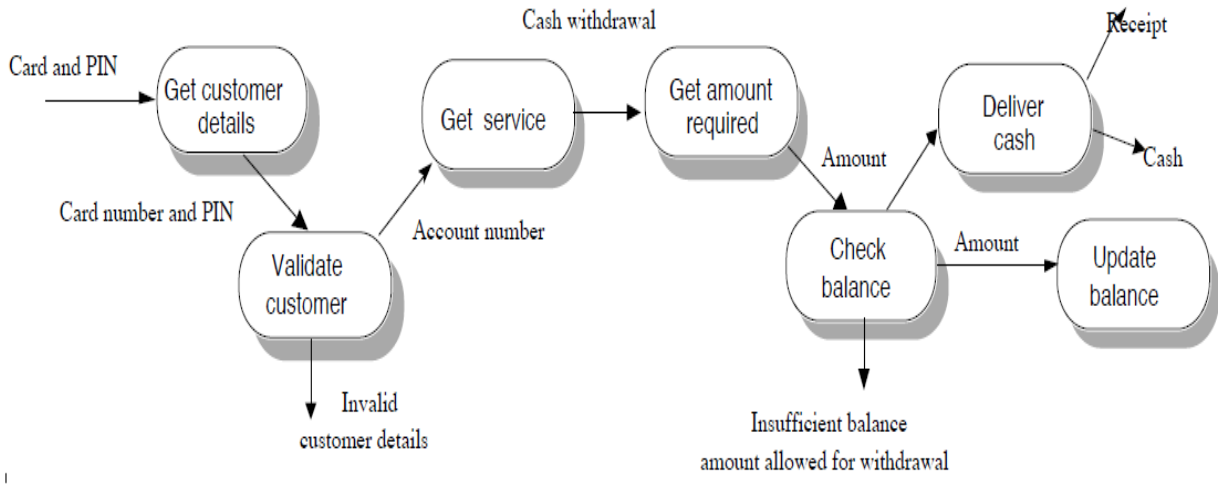
The essential difference is that in generic software product development, the specification is owned by the product developer. For custom product development, the specification is owned by the customer. Of course, there may be differences in development processes but this is not necessarily the case. [2 mks]

b.Draw a context model for a patient information system in a hospital. You may make any reasonable assumptions about the other hospital systems that are available, but your model must include a patient admissions system and an image storage system for X-rays, as well as other diagnostic records [5mks]



[5mks]

c). Based on your experience with a bank ATM, draw a data-flow diagram modelling the data processing involved when a customer withdraws cash from the machine. [7mks]



[7 mks]

d). Use the Testing Scenario below to generate at least five (5) Test Cases for a System Test on Project Management System (PMS).

A final year student in CIS department is working on a project. The student is stock and needs to get copies of previous projects related to his work. CIS department has a system called PMS that manages previous projects. He logs on to the system and is able to use the search facility of PMS to find e-copies of related projects. He is allowed to download only three copies per day. If he needs more then he uses a module in PMS that requests for permission and registers his request. If granted he has privilege to download only two more for that day.

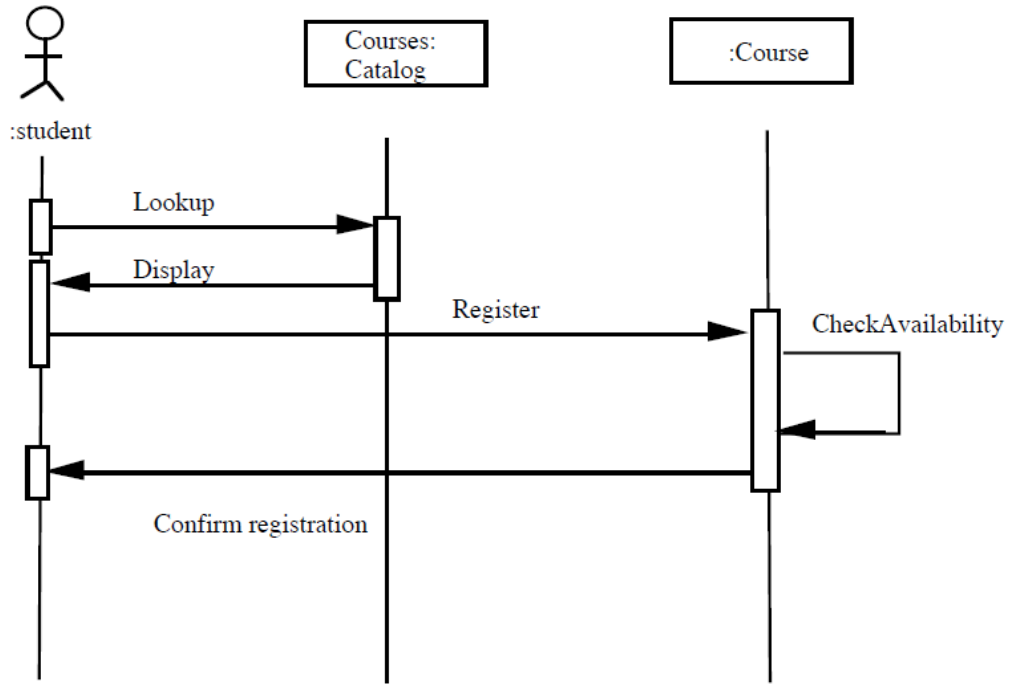
[5mks]

Test case for PMS

i) Test the login mechanism using correct and incorrect logins to check that valid users are accepted and invalid users are rejected. [1mk]
ii) Test the search facility using different queries against known sources to check that the search mechanism is actually finding documents. [1 mk]
iii) Test the system presentation facility to check that information about the projects is displayed properly. [1 mk]
iv) Test the mechanism for requesting for permission to download additional projects [1mk]
v) Test the system mechanism that grants permission download additional projects to ensure that only additional two projects are allowed for download after the initial three. [1 mk]

2a. Develop a sequence diagram showing the interactions involved when a student registers for a course in a university. Courses may have limited enrolment, so the registration process must include checks that places are available. Assume that the student accesses an electronic course catalogue to find out about available courses.

[5mks]



[5 mks]

b.i) Discuss the major challenges facing Software Engineering. [6mks]

- The heterogeneity challenge: Increasingly, systems are required to operate as distributed systems across networks that include different types of computers and with different kinds of support systems. It is often necessary to integrate new software with older legacy systems written in different programming languages. The heterogeneity challenge is the challenge of developing techniques for building dependable software that is flexible enough to cope with this heterogeneity. [2 mks]

- The delivery challenge: Many traditional software engineering techniques are time-consuming. The time they take is required to achieve software quality. However, businesses today must be responsive and change very rapidly. Their supporting software must change equally rapidly. The delivery challenge is the challenge of shortening delivery times for large and complex systems without compromising system quality. [2 mks]

- The trust challenge: As software is intertwined with all aspects of our lives, it is essential that we can trust that software. This is especially true for remote software systems accessed through a web page or web service interface. The trust challenge is to develop techniques that demonstrate that software can be trusted by its users. [2 mks]

ii) State the differences between the following: i) User Requirement and System Requirements
ii) Functional and Non-functional Requirements [4mks]

- User requirements are statements, in a natural language plus diagrams, of what services the system is expected to provide and the constraints under which it must operate. [1 mk]

- System requirements set out the system's functions, services and operational constraints in detail. The system requirements document (sometimes called a functional specification) should be precise. It should define exactly what is to be implemented. It may be part of the contract between the system buyer and the software developers. [1 mk]

- Functional requirements - these are statements of services the system should provide, how the system should react to particular inputs and how the system should behave in particular situations. In some cases, the functional requirements may also explicitly state what the system should not do. [1 mk]

- Non-functional requirements - these are constraints on the services or functions offered by the system. They include timing constraints, constraints on the development process and standards.

Non-functional requirements often apply to the system as a whole. They do not usually just apply to individual system features or services. [1 mk]

3a. Discuss the following software development process models. Include appropriate diagrams.
i) Waterfall Model ii) Spiral Model
[10mks]

Waterfall Model

The first published model of the software development process was derived from more general system engineering processes. Because of the cascade from one phase to another, this model is known as the waterfall model or software life cycle. The principal stages of the model map onto fundamental development activities:

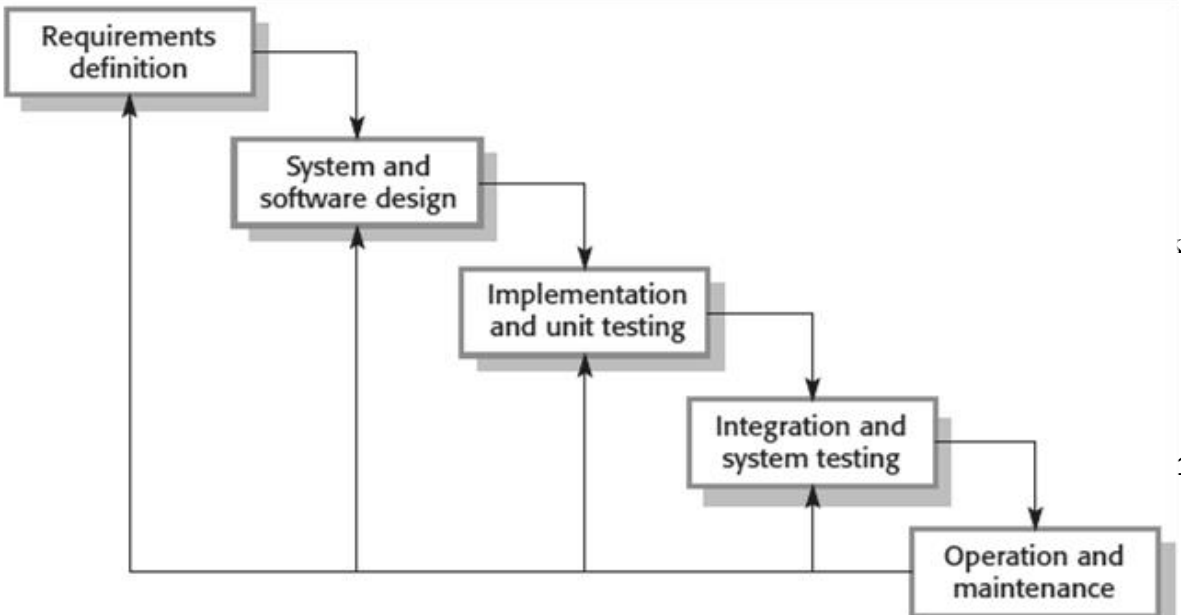
i) Requirements analysis and definition - the system's services, constraints and goals are established by consultation with system users. They are then defined in detail and serve as a system specification. [1/2 mk]

ii) System and software design - the systems design process partitions the requirements to either hardware or software systems. It establishes an overall system architecture. Software design involves identifying and describing the fundamental software system abstractions and their relationships. [1/2 mk]

iii) Implementation and unit testing - during this stage, the software design is realized as a set of programs or program units. Unit testing involves verifying that each unit meets its specification. [1/2 mk]

iv) Integration and system testing - the individual program units or programs are integrated and tested as a complete system to ensure that the software requirements have been met. After testing, the software system is delivered to the customer. [1/2 mk]

v) Operation and maintenance - normally (although not necessarily) this is the longest life-cycle phase. The system is installed and put into practical use. Maintenance involves correcting errors which were not discovered in earlier stages of the life cycle, improving the implementation of system units and enhancing the system's services as new requirements are discovered. [1/2 mk]



Spiral Model

The spiral model of the software process was originally proposed by Boehm. Rather than represent the software process as a sequence of activities with some backtracking from one activity to another, the process is represented as a spiral. Each loop in the spiral represents a phase of the software process. Thus, the innermost loop might be concerned with system feasibility, the next loop with requirements definition, the next loop with system design and so on. Each loop in the spiral is split into four sectors:

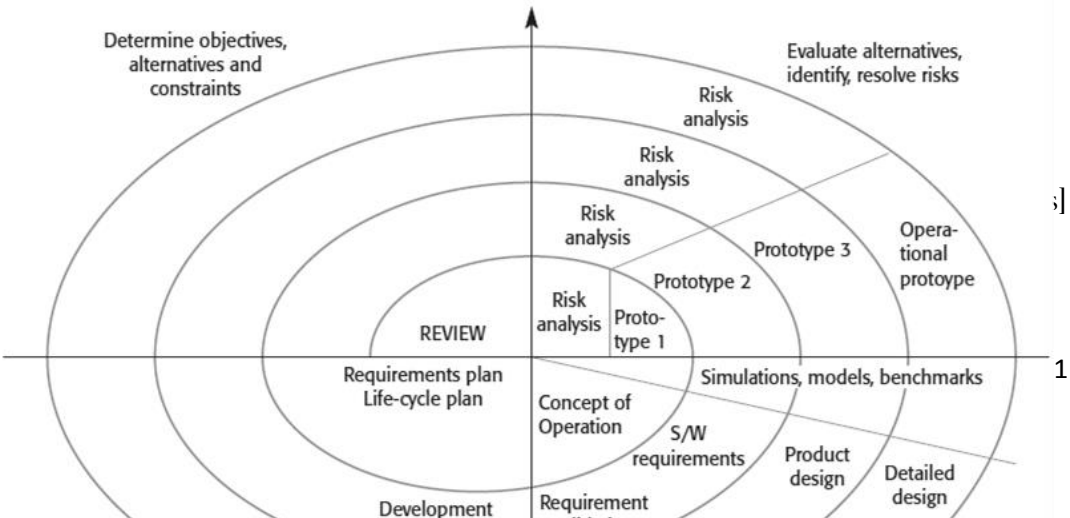
1. Objective setting Specific objectives for that phase of the project are defined. Constraints on the process and the product are identified and a detailed management plan is drawn up. Project risks are identified. Alternative strategies, depending on these risks, may be planned. [½ mk]

2. Risk assessment and reduction - for each of the identified project risks, a detailed analysis is carried out. Steps are taken to reduce the risk. For example, if there is a risk that the requirements are inappropriate, a prototype system may be developed. [½ mk]

3. Development and validation - after risk evaluation, a development model for the system is chosen. For example, if user interface risks are dominant, an appropriate development model might be evolutionary prototyping. If safety risks are the main consideration, development based on formal transformations may be the most appropriate and so on. [½ mk]

4. Planning - the project is reviewed and a decision made whether to continue with a further loop of the spiral. If it is decided to continue, plans are drawn up for the next phase of the project. [½ mk]

The main difference between the spiral model and other software process models is the explicit recognition of risk in the spiral model. Informally, risk simply means something that can go wrong. For example, if the intention is to use a new programming language, a risk is that the available compilers are unreliable or do not produce sufficiently efficient object code. Risks result in project problems such as schedule and cost overrun so risk minimisation is a very important project management activity. [½ mk]



b. Suggest who might be stakeholders in a university student records system. Explain hy it is almost inevitable that the requirements of different stakeholders will conflict in some way.
[5mks]

The stakeholders in a student records system include:

• University central administration including those responsible for registration, payment of fees, examinations and assessment and graduation. [1 mk]

• The students whose details are recorded in the system. [1 mk]

• University departmental administrators who supply information to the system and use information from it.
[1 mk]

• Academic staff who use information from the system. [½ mk]

• Data protection officers (local and national). [½ mk]

• Potential employers of students (who may require information from the system). [1 mk]

4a i)Explain why the rapid delivery and deployment of news systems is often more important to businesses than detailed functionality of these systems.
[4mks]

Software development processes that are based on completely specifying the requirements then designing, building and testing the system are not geared to rapid software development. As the requirements change or as requirements problems are discovered, the system design or implementation has to be reworked and retested. As a consequence, a conventional waterfall or specification-based process is usually prolonged and the final software is delivered to the customer long after it was originally specified. [2 mks]

In a fast-moving business environment, this can cause real problems. By the time the software is available for use, the original reason for its procurement may have changed so radically that the software is effectively useless. Therefore, for business systems in particular, development processes that focus on rapid software development and delivery are essential. [1 mk]

Rapid software development processes are designed to produce useful software quickly. Generally, they are iterative processes where specification, design, development and testing are interleaved. The software is not developed and deployed in its entirety but in a series of increments, with each increment including new system functionality. [1 mk]

ii)When is it appropriate not to recommend agile method for developing a software system? [3mks]

Agile methods should not be used when the software is being developed by teams who are not co-located – if any of these teams use agile methods, it is very difficult to coordinate their work with other teams[1 mk]. Agile methods should probably also be avoided for critical systems where the consequences of a specification error are serious. [1 mk]In those circumstances, a system specification that is available before development starts makes a detailed specification analysis possible. However, some ideas from agile approaches such as test first development are certainly applicable to critical systems [1 mk].

b i)Suggest four (4) reasons why the productivity rate of programmers working as a pair is roughly the same as two programmers working individually. [4mks]

Reasons why pair programming is as efficient as the same number of programmers working individually:

- Pair programming leads to continuous informal reviewing. This discovers bugs more quickly than individual testing. [1 mk]
- Information sharing in pair programming is implicit – it happens during the process. Individual programmers have to spend time explicitly sharing information. [1 mk]
- Pair programming encourages refactoring (the code must be understandable to another person). This reduces the costs of subsequent development and change. [1 mk]
- In pair programming, people are likely to spend less time in fine-grain optimization as this does not benefit the other programmer. [1 mk]

ii)Extreme programming expresses user requirements as stories, with each story written on a card. Discuss the advantages and disadvantages of this approach to requirements description. [4mks]

Advantages of stories:

- They represent real situations that commonly arise so the system will support the most common user operations. [1 mk]
- It is easy for users to understand and critique the stories. [½ mk]
- They represent increments of functionality – implementing a story delivers some value to the user.

[½ mks]

Disadvantages of stories

- They are liable to be incomplete and their informal nature makes this incompleteness difficult to detect. [½ mk]
- They focus on functional requirements rather than non-functional requirements. [½ mk]
- Representing cross-cutting system requirements such as performance and reliability is impossible when stories are used. [½ mk]
- The relationship between the system architecture and the user stories is unclear so architectural design is difficult. [½ mk]

5ai) Discuss the differences between verification and validation, and explain why validation is a particularly difficult process. [4mks]

Verification is demonstrating conformance to a specification whereas validation is checking that a system meets the customer's needs[1 mk]. Validation is difficult because there are many different stakeholders who may use the system with different needs[1 mk]. Therefore, a system that meets one user's needs may not meet the needs of a different user. Furthermore, needs change as a system is developed so the needs as identified when the system was specified may be different by the time that the system is tested. [2 mks]

ii) Explain why it is not necessary for a program to be completely free of defects before it is delivered to its customers. To what extent can testing be used to validate that the program is fit for its purpose? [6mks]

A program need not be completely free of defects before delivery if:
i). Remaining defects are minor defects that do not cause system corruption and which are transient i.e. which can be cleared when new data is input. [1 mk]
ii). Remaining defects are such that they are recoverable and a recovery function that causes minimum user disruption is available. [1 mk]
iii).The benefits to the customer's business from the system exceed the problems that might be caused by remaining system defects. [1 mk]

Testing cannot completely validate that a system is fit for its intended purpose as this requires a detailed knowledge of what that purpose will be and exactly how the system will be used. As these details inevitably change between deciding to procure a system and deploying that system, the testing will be necessarily incomplete. In addition, it is practically impossible for all except trivial system to have a complete test set that covers all possible ways that the system is likely to be used. [3 mks]

bi) Explain why program inspections are an effective technique for discovering errors in a program. [5mks]

Program inspections are effective for the following reasons:

i)They can find several faults in one pass without being concerned about interference between program faults. [1 ½ mks]

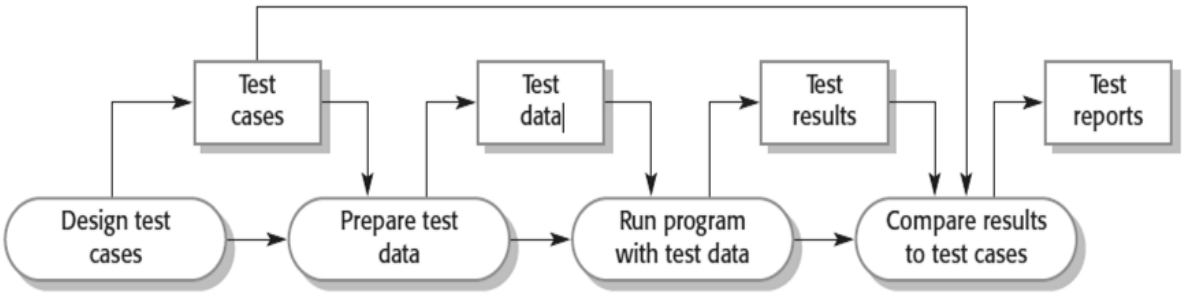
ii)They bring a number of people with different experience of different types of errors. Hence, the team approach offers greater coverage than any individual can bring. [1 ½ mks]

iii)They force the program author to re-examine the program in detail - this often reveals errors or misunderstandings. [1 ½ mks]

The types of errors that inspections are unlikely to find are specification errors or errors that are based on a misunderstanding of the application domain (unless there are domain experts in the team) [½ mk]

6a. Explain the Software Testing Process. Include the appropriate diagram [6mks]

Test cases are specifications of the inputs to the test and the expected output from the system plus a statement of what is being tested [1 mk]. Test data are the inputs that have been devised to test the system. Test data can sometimes be generated automatically [1 mk]. Automatic test case generation is impossible. The output of the tests can only be predicted by people who understand what the system should do. Exhaustive testing, where every possible program execution sequence is tested, is impossible. Testing, therefore, has to be based on a subset of possible test cases. Ideally, software companies should have policies for choosing this subset rather than leave this to the development team. [1 mk]



ıks]

bi) Differentiate between White Box and Black Box Testing [5mks]

The Differences Between Black Box Testing and White Box Testing are listed below.

Criteria	Black Box Testing	White Box Testing
Definition	Black Box Testing is a software testing method in which the internal structure/ design/ implementation of the item being tested is NOT known to the tester	White Box Testing is a software testing method in which the internal structure/ design/ implementation of the item being tested is known to the tester.
Levels Applicable To	Mainly applicable to higher levels of testing:Acceptance Testing System Testing	Mainly applicable to lower levels of testing:Unit Testing Integration Testing
Responsibility	Generally, independent Software Testers	Generally, Software Developers
Programming Knowledge	Not Required	Required
Implementation Knowledge	Not Required	Required
Basis for Test Cases	Requirement Specifications	Detail Design

[1 mks]

[1mk]

[1 mk]

[1 mk]
[1 mk]

ii) Explain why interface testing is necessary even when individual components have been extensively validated through component testing and program inspections.
[4mks]

There are several reasons why interface testing is a necessary stage after unit testing:

- The interface to the module may have been incorrectly specified. The validation process is based on this specification rather than actual usage of the module or sub-system. [2 mks]

• The assumptions made by other modules about the behaviour of a given module (A say) in response to particular interface stimuli may be incorrect. That is, these modules expect A to behave in a way in which it was never designed to operate. [1mk]

• Interface testing can reveal omissions in the interface design. It may be discovered, when integrated with other modules, that the interface must be augmented in some way. [1mk]

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COLLEGE: SCEINCE AND TECHNOLOGY
SCHOOL: NATURAL AND APPLIED SCIENCES
DEPARTMENT: COMPUTER AND INFORMATION SCIENCES
SESSION: 2014/2015 **SEMESTER: ALPHA**
COURSE CODE: CSC 411 **CREDIT UNIT: 3 Units**
COURSE TITLE: SOFTWARE ENGINEERING
INSTRUCTION: ANSWER QUESTION ONE (1) AND ANY OTHER THREE (3) QUESTIONS Time: 3 Hours

1. **Attempt any two case studies from the options (a-c) given as follows:**
   a. Describe a package of software-controlled instruments for Weather station. Briefly explain the weather station object classes. Demonstrate all classes with diagram.
      (12.5marks)
   b. What do you understand by Form-based specification and Tabular specification? Give an example of computing insulin dose: Safe sugar level for a sugar patient.
      (12.5marks)
   c. By giving example of library: 1. Explain requirements based testing 2. Summarize the LIBSYS requirements 3. LIBSYS tests
      (12.5marks)

2.
   a. Write down the key attributes of 'good' software. Summarize the key challenges which software engineering is facing.
      (5marks)
   b. Summarize the ethical and profession responsibilities of a software engineer.
      (5marks)
   c. Describe (with diagram) the spiral model. Show all stages of spiral model.
      (5marks)

3.
   a. What do you understand by context model? Explain context model by giving an example.
      (5marks)
   b. Define the process model. Draw process model for equipment procurement process.
      (5marks)
   c. Explain state machine model and give an example of Microwave oven (draw state machine model for microwave oven).
      (5marks)

4.

a. Define the architectural design and software architecture. Summarize the architecture and system characteristics. **(5marks)**

b. Summarize the questions for architecture design decision. Discuss different types of architecture models. **(5marks)**

c. What do you understand by the repository model? Give an example of CASE tool architecture. Summarize repository model characteristics.
(5marks)

5.

a) Why is there a need for rapid action software development? Explain the Characteristics of RAD processes. **(5marks)**

b) Show the diagram for an iterative development process. Summarize advantages and disadvantages of iterative development processes.
(5marks)

c) What do you understand by agile method? Summarize the principles of agile methods.
(5marks)

6.

a. What do you understand by non-functional requirement classifications? Show a tree diagram of the non-functional requirements classification.
(5marks)

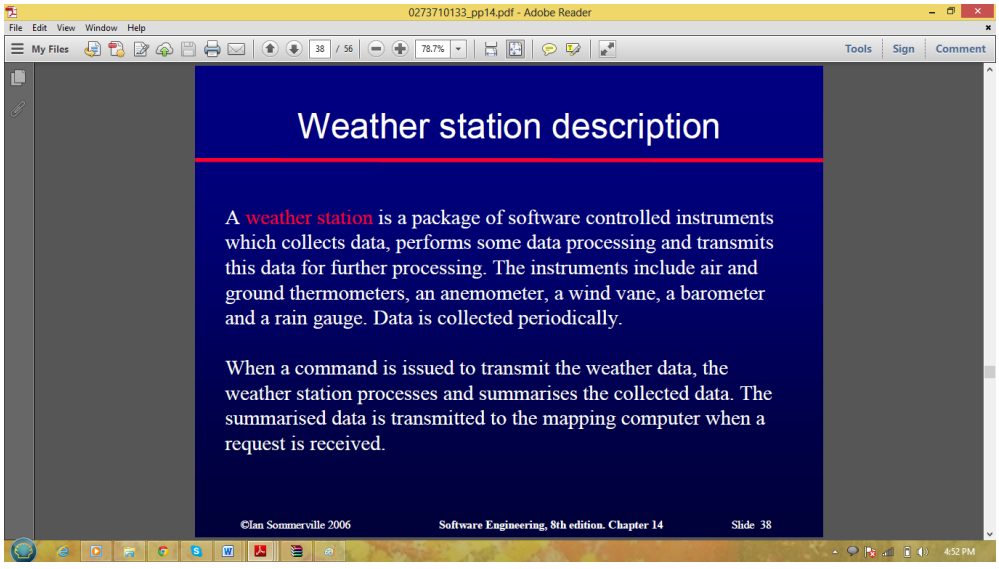
b. What is the difference between testing and debugging? Summarize the structure of a software test plan. Explain each step in brief.
(5marks)

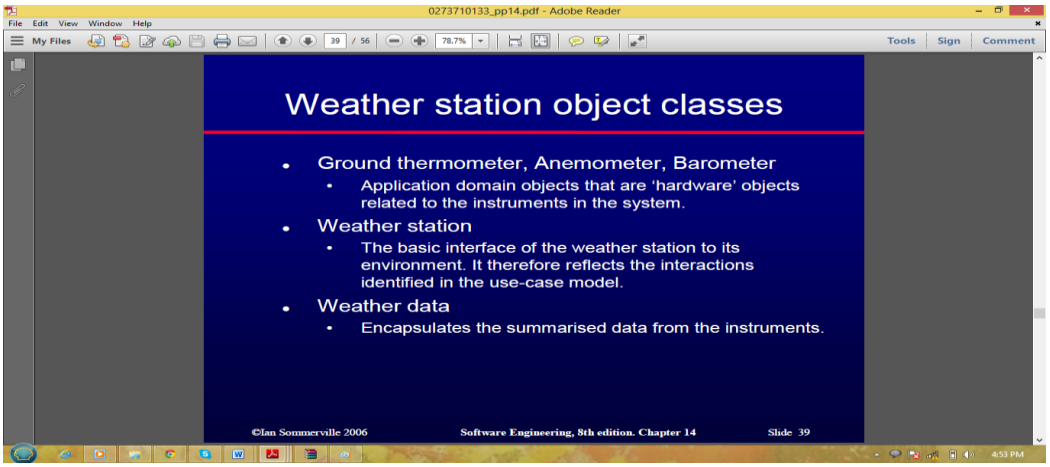
c. Summarize in brief: 1) Performance testing 2) Stress Testing 3) Component testing and 4) Object class testing **(5marks)**

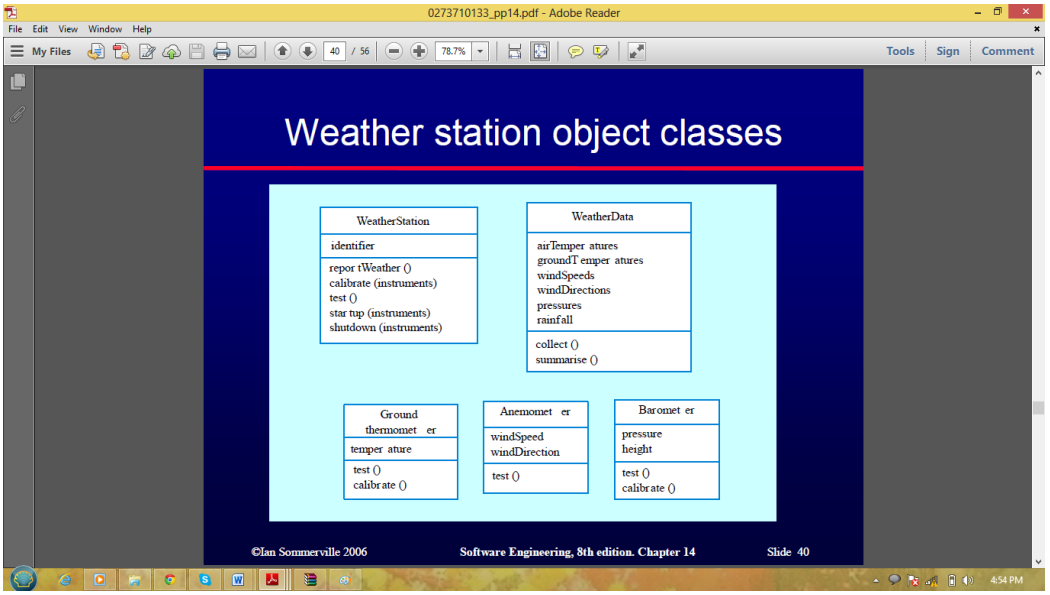
CSC411 Marking Guide for 2014/2015

Question 1 **(2 x 12.5 marks)**

1a.







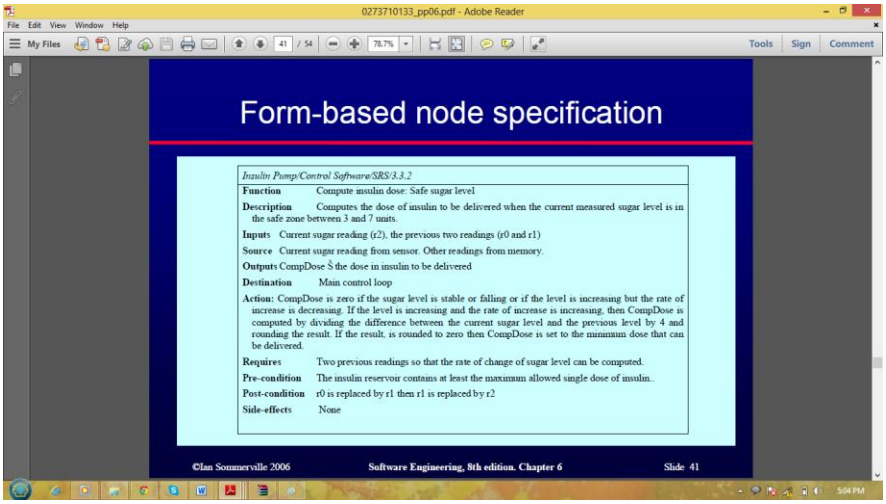
1b

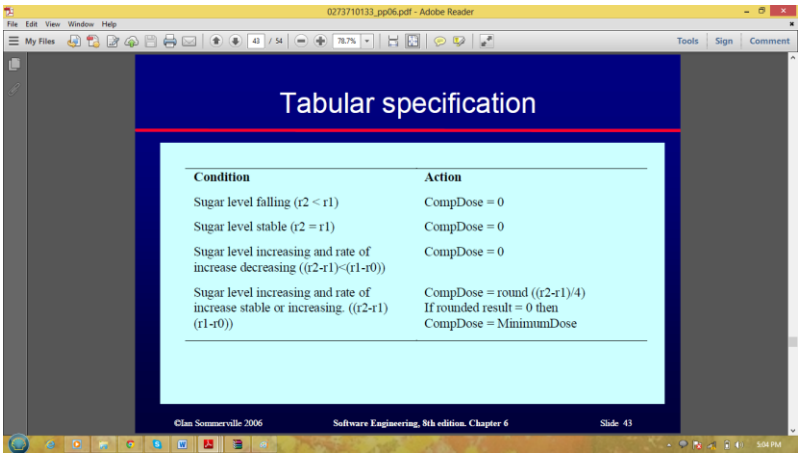
Form based specifications

- Definition of the function or entity.
- Description of inputs and where they come from.
- Description of outputs and where they go to.
- Indication of other entities required.
- Pre and post conditions (if appropriate).
- The side effects (if any) of the function.

Tabular specification

- Used to supplement natural language.
- Particularly useful when you have to define a number of possible alternative courses of action.



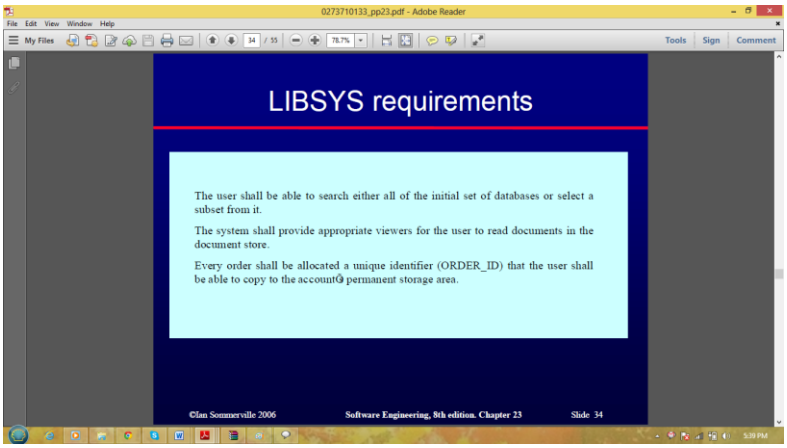


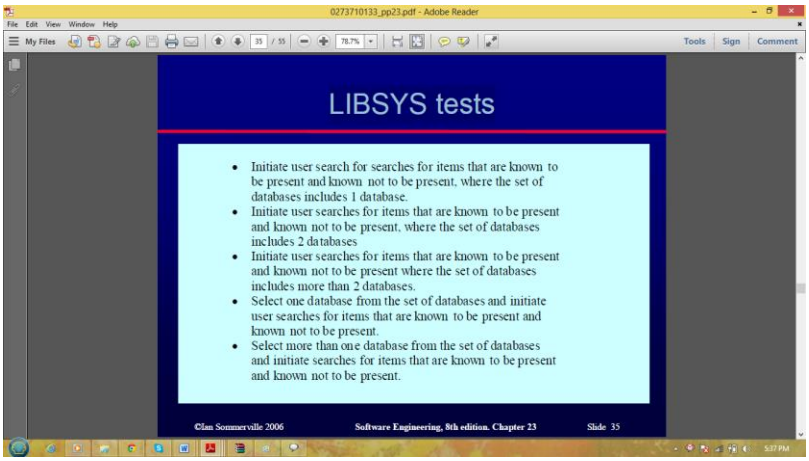
1c

Requirements based testing

- A general principle of requirements engineering is that requirements should be testable.
- Requirements based testing is a validation testing technique where you consider each requirement and derive a set of tests for that requirement.

LIBSYS tests





Ans 2 a

What are the attributes of good software?

The software should deliver the required functionality and performance to the user and should be maintainable, dependable and acceptable.

- Maintainability: Software must evolve to meet changing needs;
- Dependability: Software must be trustworthy;
- Efficiency: Software should not make wasteful use of system resources;
- Acceptability: Software must accepted by the users for which it was designed.

This means it must be understandable, usable and compatible with other systems.

Heterogeneity, delivery and trust.

Heterogeneity

• Developing techniques for building software that can cope with heterogeneous platforms and execution environments;

Delivery

• Developing techniques that lead to faster delivery of software;

Trust

• Developing techniques that demonstrate that software can be trusted by its users

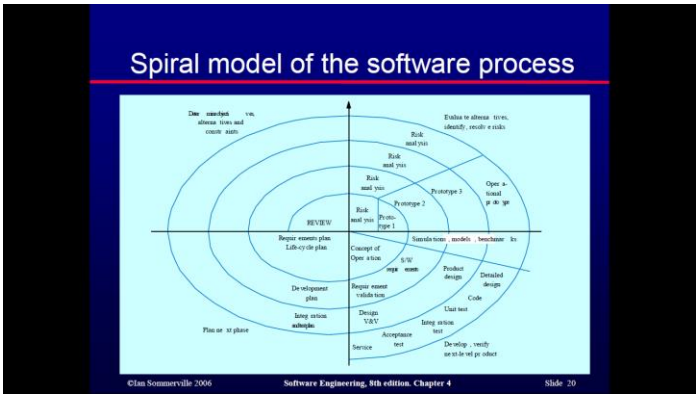
2 b: Software engineering involves wider responsibilities than simply the application of technical skills. l Software engineers must behave in an honest and ethically responsible way if they are to be respected as professionals.

Ethical behaviour is more than simply upholding the law.

Confidentiality: Engineers should normally respect the confidentiality of their employers or clients irrespective of whether or not a formal confidentiality agreement has been signed.
Competence: Engineers should not misrepresent their level of competence. They should not knowingly accept work, which is out with their competence.
Intellectual property rights: Engineers should be aware of local laws governing the use of intellectual property such as patents, copyright, etc. They should be careful to ensure that the intellectual property of employers and clients is protected.
Computer misuse: Software engineers should not use their technical skills to misuse other people's computers. Computer misuse ranges from relatively trivial (game playing on an employer's machine, say) to extremely serious (dissemination of viruses).

2c:
Process is represented as a spiral rather than as a sequence of activities with backtracking.

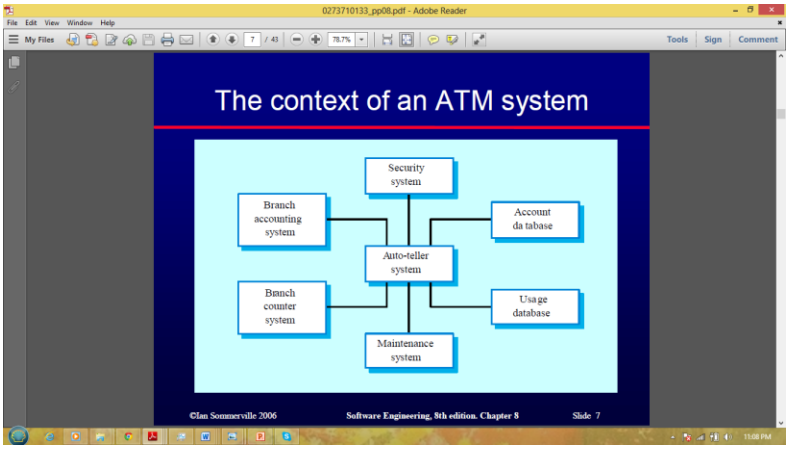
- Each loop in the spiral represents a phase in the process.
- No fixed phases such as specification or design loops in the spiral are chosen depending on what is required.
- Risks are explicitly assessed and resolved throughout the process.



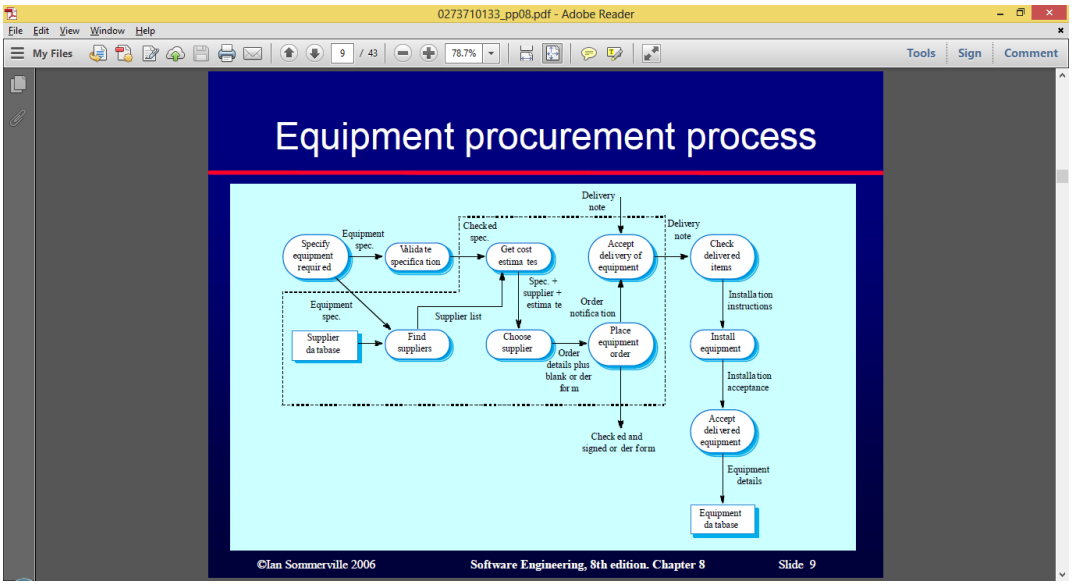
Ans 3a.

Context model

- Context models are used to illustrate the operational context of a system they show what lies outside the system boundaries.
- Social and organisational concerns may affect the decision on where to position system boundaries.
- Architectural models show the system and its relationship with other systems.



3 b. Process models show the overall process and the processes that are supported by the system.
Data flow models may be used to show the processes and the flow of information from one process to another.



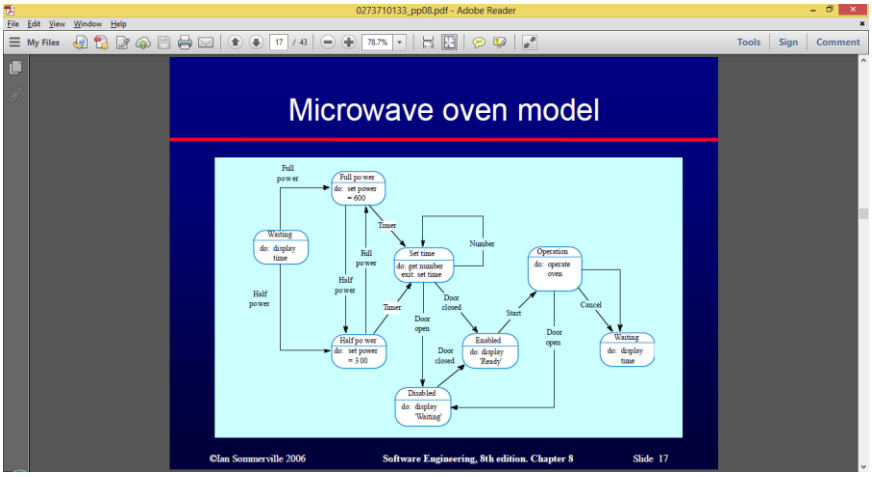
3 c. State Machine model

These model the behavior of the system in response to external and internal events.

They show the system's responses to stimuli so are often used for modelling real time systems.

State machine models show system states as nodes and events as arcs between these nodes. When an event occurs, the system moves from one state to another.

Statecharts are an integral part of the UML and are used to represent state machine models.



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4 a. The design process for identifying the subsystems making up a system and the framework for subsystem control and communication is architectural design.

The output of this design process is a description of the software architecture.

Performance: Localise critical operations and minimise communications. Use large rather than fine-grain components.
Security: Use a layered architecture with critical assets in the inner layers.
Safety: Localise safety critical features in a small number of subsystems.
Availability: Include redundant components and mechanisms for fault tolerance.
Maintainability: Use fine grain, replaceable components.

Ans 4b

- Is there a generic application architecture that can be used?
- How will the system be distributed?
- What architectural styles are appropriate?
- What approach will be used to structure the system?
- How will the system be decomposed into modules?
- What control strategy should be used?
- How will the architectural design be evaluated?
- How should the architecture be documented?

Types of Architecture models

Used to document an architectural design.

- Static structural model that shows the major system components.
- Dynamic process model that shows the process structure of the system.
- Interface model that defines subsystem interfaces.
- Relationships model such as a dataflow model that shows subsystem relationships.
- Distribution model that shows how subsystems are distributed across computers.

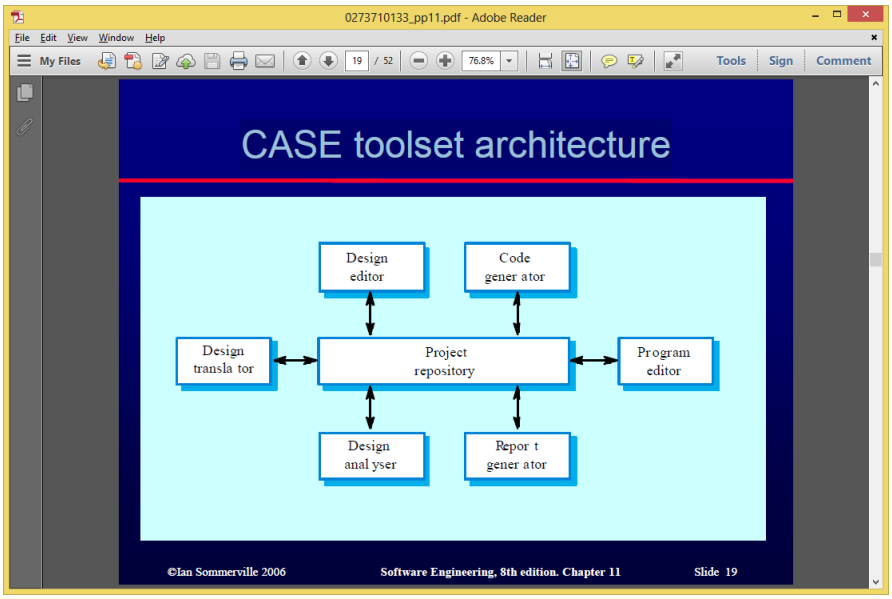
Ans 4c

Subsystems must exchange data. This may be done in two ways:

• Shared data is held in a central database or repository and may be accessed by all subsystems;

- Each subsystem maintains its own database and passes data explicitly to other subsystems.

When large amounts of data are to be shared, the repository model of sharing is most commonly used.



Advantages

• Efficient way to share large amounts of data;
• Subsystems need not be concerned with how data is produced. Centralised management e.g. backup, security, etc.
• Sharing model is published as the repository schema.

Disadvantages

• Subsystems must agree on a repository data model.
Inevitably a compromise;
• Data evolution is difficult and expensive;
• No scope for specific management policies;
• Difficult to distribute efficiently

Ans 5 a

Because of rapidly changing business environments, businesses have to respond to new opportunities and competition.

This requires software and rapid development and delivery is not often the most critical requirement for software systems.

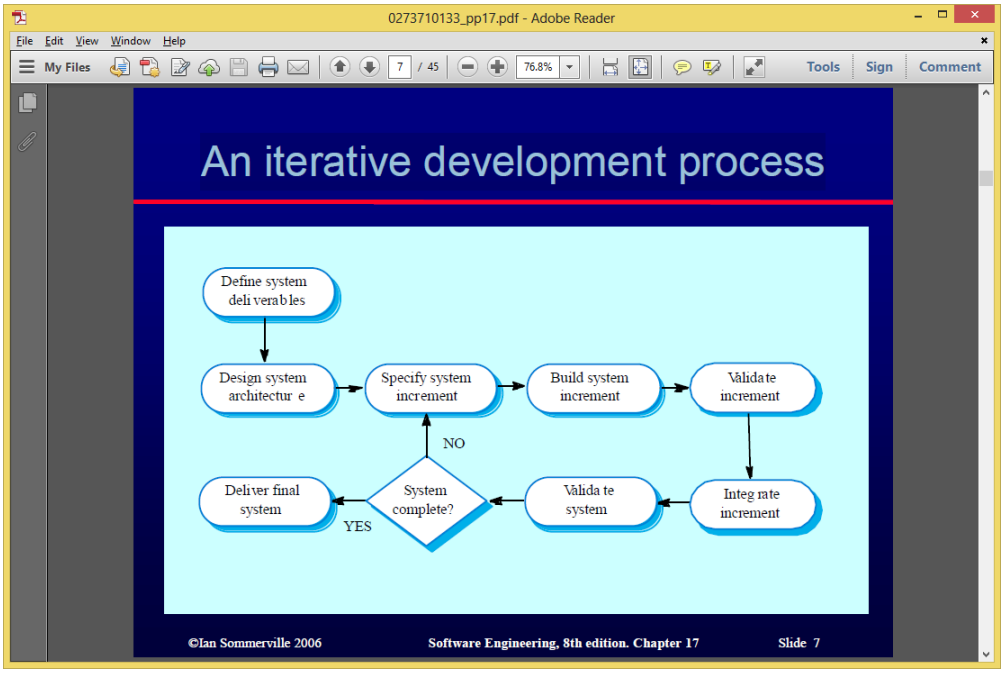
Businesses may be willing to accept lower quality software if rapid delivery of essential functionality is possible.

The processes of specification, design and implementation are concurrent. There is no detailed specification and design documentation is minimised.

The system is developed in a series of increments. End users evaluate each increment and make proposals for later increments.

System user interfaces are usually developed using an interactive development system.

5b.

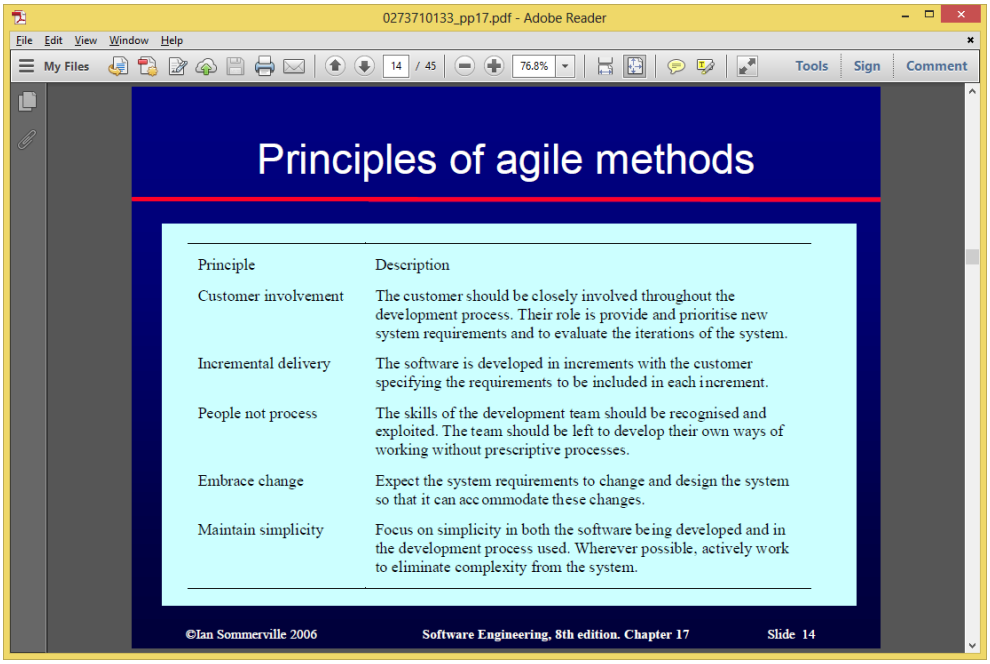


Advantages:
Accelerated delivery of customer services: Each increment delivers the highest priority functionality to the customer.
User engagement with the system: Users have to be involved in the development, which means the system is more likely to meet their requirements and the users are more committed to the system.

Problems:
Management problems
• Progress can be hard to judge and problems hard to find because there is no documentation to demonstrate what has been done.
Contractual problems
• The normal contract may include a specification; without a specification, different forms of contract have to be used.
Validation problems
• Without a specification, what is the system being tested against?
Maintenance problems
• Continual change tends to corrupt software structure making it more expensive to change and evolve to meet new requirements.

_____
5 c
Dissatisfaction with the overheads involved in design methods led to the creation of agile methods. These methods:
• Focus on the code rather than the design;
• Are based on an iterative approach to software development;
• Are intended to deliver working software quickly and evolve this quickly to meet changing requirements.

Agile methods are probably best suited to small/medium sized business systems or PC products.

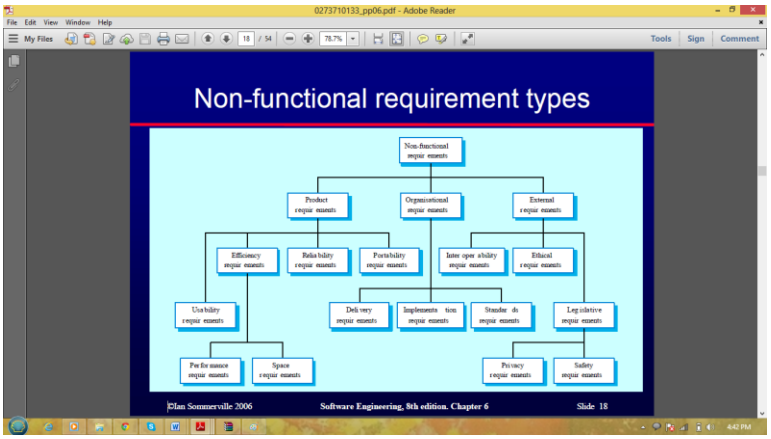


6a.
These define system properties and constraints e.g. reliability, response time and storage requirements. Constraints are I/O device capability, system representations, etc.

- Process requirements may also be specified mandating a particular CASE system, programming language or development method.
- Nonfunctional requirements may be more critical than functional requirements. If these are not met, the system is useless.

Classifications:

Product requirements
• Requirements which specify that the delivered product must behave in a particular way e.g. execution speed, reliability, etc.
Organizational requirements
• Requirements which are a consequence of organizational policies and procedures e.g. process standards used, implementation requirements, etc.
External requirements
• Requirements which arise from factors which are external to the system and its development process e.g. interoperability requirements, legislative requirements, etc.



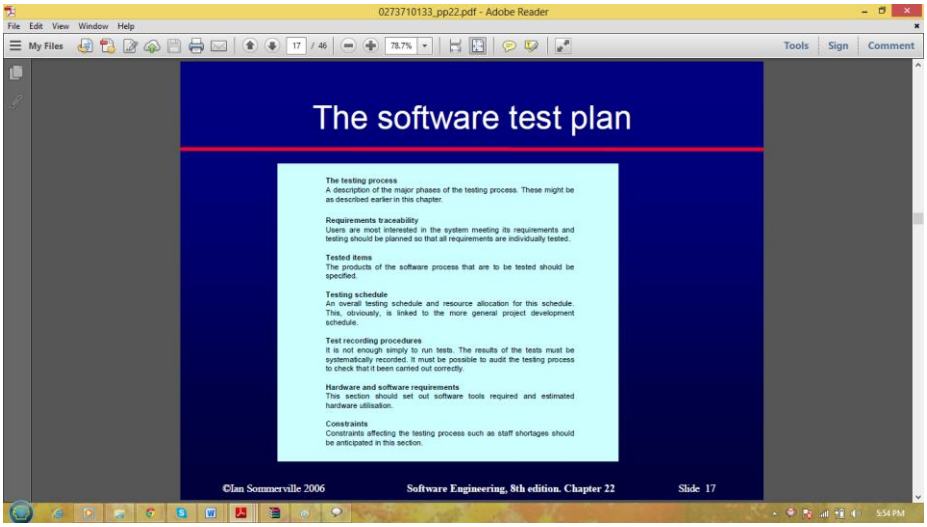
6b.

Defect testing and debugging are distinct processes.

- Verification and validation is concerned with establishing the existence of defects in a program.
- Debugging is concerned with locating and repairing these errors.
- Debugging involves formulating a hypothesis about program behavior then testing these hypotheses to find the system error.

The structure of a software test plan

- The testing process.
- Requirements traceability.
- Tested items.
- Testing schedule.
- Test recording procedures.
- Hardware and software requirements.
- Constraints.



6c. Performance testing

- Part of release testing may involve testing the emergent properties of a system, such as performance and reliability.
- Performance tests usually involve planning a series of tests where the load is steadily increased until the system performance becomes unacceptable.

Stress testing

- Exercises the system beyond its maximum design load. Stressing the system often causes defects to come to light.
- Stressing the system test failure behaviour.
- Systems should not fail catastrophically. Stress testing checks for unacceptable loss of service or data.
- Stress testing is particularly relevant to distributed systems that can exhibit severe degradation as a network becomes overloaded.

Component testing
Component or unit testing is the process of testing individual components in isolation.
It is a defect testing process.
Components may be:

- Individual functions or methods within an object;
- Object classes with several attributes and methods;
- Composite components with defined interfaces used to access their functionality.

Object class testing

Complete test coverage of a class involves
• Testing all operations associated with an object;
• Setting and interrogating all object attributes;
• Exercising the object in all possible states.
Inheritance makes it more difficult to design object class tests as the information to be tested is not localised.

COVENANT UNIVERSITY

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P.M.B 1023, OTA, OGUN STATE, NIGERIA.

TITLE OF EXAMINATION: B.Sc EXAMINATION
COLLEGE: College of Science and Technology
DEPARTMENT: Department of Computer and Information Sciences
SESSION: 2015/2016 **SEMESTER:** ALPHA
COURSE CODE: CSC 413 **CREDIT UNIT:** 3
COURSE TITLE: Algorithm & Complexity Analysis
INSTRUCTION: Answer ANY 4 questions **TIME**: 3 HOURS

---

1. (a) Briefly describe the following;
   i. An algorithm
   ii. Analysis of algorithm
   iii. Time & Space Complexity
   iv. Correct / In-correct algorithm (3 marks)

   (b) Give the formal definition and graphical representation of the asymptotic notations you know. ($6^1/_2$ marks)

   (c) i. Prove that if $f(n) = 15n^3 + n^2 + 4$, $f(n) = O(n^3)$
   ii. Show that $30n+8$ is $O(n)$.
   iii. Show that $100n + 5 \neq \Omega(n2)$ (6 marks)

   (d) Arrange the growth rate of these functions in ascending order.
   $O(2^n)$, $O(n \log n)$, $O(n^2)$, $O(\log n)$, $O(n)$, $O(n^3)$ (2 marks)

2. (a) Explain the Divide and Conquer paradigm, stating its merits and demerits. Give examples of algorithms that employ the divide and conquer technique. (5 marks)

   (b) What is the general divide and conquer recurrence relation? ($2^1/_2$ marks)

   (c) Strassen's algorithm shows how to multiply two n by n matrices by multiplying 7 pairs of n/2 by n/2 matrices, and then doing n^2 operations to combine them. What is the running time of the Strassen's matrix multiplication algorithm (4 marks)

   (d) Write the recurrence equation for the Divide and Conquer algorithm below. Hence, find its running time. (6 marks)

   Convex Hull Algorithm
   Hull(S) : Given an input of size n
   (1) If $|S| <= 3$, then compute the convex hull by brute force in O(1)time and return.
   (2) Otherwise, partition the point set S into two sets A and B, where A consists of half the points with the lowest x coordinates and B consists of half of the points with the highest x coordinates.
   (3) Recursively compute HA = Hull(A) and HB = Hull(B).

(4) Merge the two hulls into a common convex hull, H, by computing the upper and lower tangents for HA and HB and discarding all the points lying between these two tangents.
Hint: the time to compute the upper and lower tangents is linear.

3. (a) Explain the term recursion? Differentiate between direct and indirect recursive algorithms. (3 marks)

(b) Write a recursive algorithm for computing the Fibonacci series. (2½ marks)

(c) Describe the Tower of Hanoi puzzle. Write an algorithm to solve this puzzle and comment on its running time. (6 marks)

(d) Consider the recursive algorithm given below:

Algorithm Parallel-Product (A[1..n])
    if n = 1 then return
    for i = 1 to $n/2$ do
        A[i] = A[i] * A[i + $n/2$];
    Call Parallel-Product (A[1.. $n/2$])

i) Write the recurrence equation.

ii) Find the time complexity for the algorithm by solving the recurrence equation using repeated substitution method. (6 marks)

4. (a) State the worst case, best case and average case of the sequential search algorithm below.

```
for i = 1 to n do
       if A [i] ≥ q then
                  return index i
      return n + 1
```

(3 marks)

(b) Given the Binary search algorithm below;

```
public int binarySearch (int target,int[] array, int low, int high)
{
     if (low > high)
        return -1;
     else {
        int middle = (low + high)/2;
        if (array[middle] == target)
           return middle;
        else if(array[middle] < target)
           return binarySearch(target, array, middle + 1, high);
        else
           return binarySearch(target, array, low, middle - 1);
       }
  }
```

i. Is it an improvement over the sequential search algorithm in 4a above? Give reasons for your answer.

ii. Comment on the conditions for the best case, average case and worst case of the binary search algorithm. (5 marks)

(c) Consider the two algorithms above for computing x raised to the power of y. Which algorithm is more efficient with respect to running time? Give reasons for your answer. (7½ marks)

Algorithm 1

```
long powerA (int x, unsigned int n)
{
   int temp;
   if( n == 0)
      return 1;
   temp = powerA(x, n/2);
   if (n%2 == 0)
      return temp*temp;
   else
      return x*temp*temp;
}
```

Algorithm 2

```
long powerB (int x, unsigned int n)
{
    long prod = 1;
    if( n == 0)
        return prod;
    for(i=1; i <= n; i++)
        prod *= x
    return prod
}
```

(d) Explain the possible reason for the time efficiency of your preferred algorithm in terms of the algorithmic paradigm employed. (2 marks)

5. (a) What is a heap? Give an example. (2½marks)

(b) Give at least five operations that can be performed on a heap with their time complexity. (5 marks)

(c) Given an array of 6 elements: 15, 19, 10, 7, 17, 16, sort it in ascending order using heap sort. (7 marks)

(d) Complete the table below. (3 marks)

Name	Worst Case	Stable	Method
Bubble Sort			
Selection Sort			
Insertion Sort			
Merge Sort			
Quick Sort			

6. (a) With the aid of clear diagram, explain the following; (7 marks)

i. Path ii. Bipartite graph iii. Cycle
iv. Complete graph v. Digraph vi. Weighted graph
vii. Spanning tree

(b) Given the graph in figure 1, give an incidence matrix representation of the graph. (2½marks)

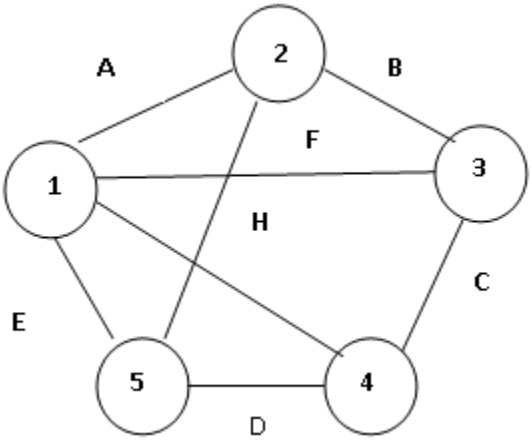

Figure 1

The weighted graph in figure 2 shows cities and the distance between them in kilometers.

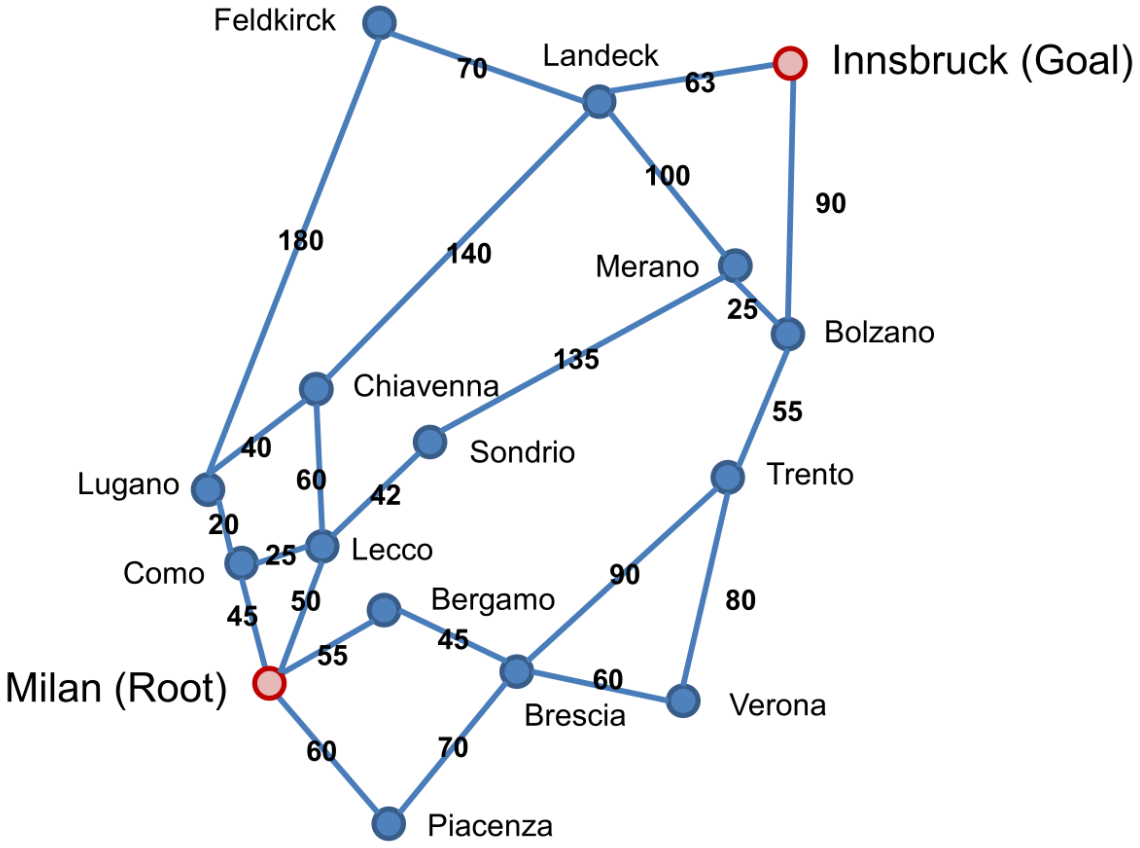

Figure 2

(c) Run the Depth-First Search (DFS) algorithm. Present a DFS tree and calculate the total distance of the route from Milan to Innsbruck. (3 marks)

(d) Run the Breadth-First Search (BFS) algorithm. Present a BFS tree and calculate the total distance of the route from Milan to Innsbruck. (5 marks)

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Marking Scheme

1a. Write short notes on the following $^1/_2$ mark each = 3 marks

i. An algorithm is a sequence of computational steps that transform the input into the output.

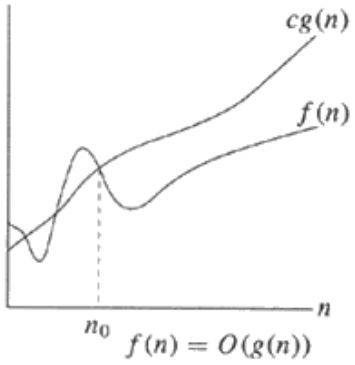
ii. Analysis of algorithms is the theoretical study of computer program performance and resource usage. To analyze an algorithm is to determine the amount of resources (such as time and storage) necessary to execute it.

iii. Time Complexity - the time complexity of an algorithm quantifies the amount of time taken by an algorithm to run as a function of the input size.
Space Complexity of an algorithm is total space taken by the algorithm with respect to the input size.

iv. An algorithm is said to be correct if, for every input instance, it halts with the correct output. We then say that a correct algorithm solves the given computational problem.
An incorrect algorithm might not halt at all on some input instances or it might halt with an answer other than the desired one.

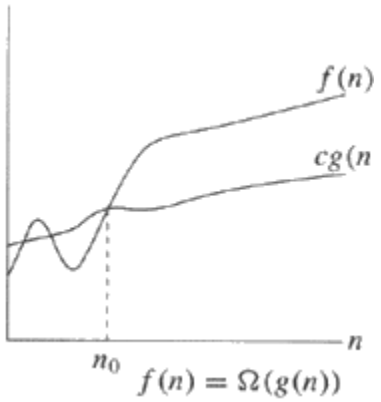
b. $1^1/_2$ mark (1-3) + 1 mark (4-5) = $6^1/_2$ marks

O-notation (upper bounds):
$O(g(n))$= { $f(n)$: there exist constants $c>0$, $n_0>0$ such that $0 \leq f(n) \leq cg(n)$for all $n \geq n_0$}



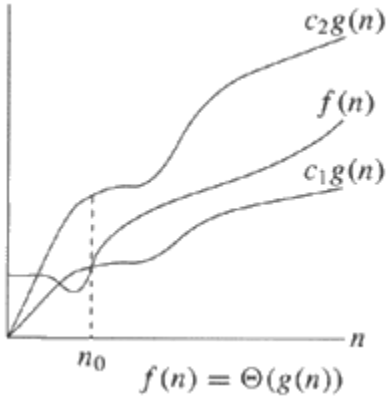
Ω-notation (lower bounds)

$\Omega(g(n))$= { $f(n)$:there exist constants $c>0$, $n_0>0$ such that $0 \le cg(n) \le f(n)$ for all $n \ge n_0$}



Θ-notation (tight bounds)

Θ(g(n)) = O(g(n)) ∩Ω(g(n))



o-notation

o($g(n)$)= { $f(n)$:for any constant $c>0$, there is a constant $n_0>0$ such that $0 \le f(n)<cg(n)$ for all $n \ge n_0$}

ω-notation

ω($g(n)$)= { $f(n)$:for any constant $c> 0$, there is a constant $n_0>0$ such that $0 \le cg(n)<f(n)$ for all $n \ge n_0$}

c. 2 marks each = 6 marks

i. Proof that if $f(n) = 15n^3 + n^2 + 4$, $f(n) = O(n^3)$

Let $c_1 = 15$, $c_2 = 20$ and $n_0 = 1$.

Must show that $c_1g(n) \leq f(n)$ and $f(n) \leq c_2g(n)$.
$c_1g(n) = 15n^3 \leq 15n^3 + n^2 + 4 = f(n)$.
$f(n) = 15n^3 + n^2 + 4 \leq 15n^3 + n^3 + 4n^3 = 20n^3 = c_2g(n)$

ii. Show $\exists$ c, n0: $30n+8 \leq cn$, $\forall n>n0$.
Let c=31, n0=8. Assume n>n0=8. Then
$cn = 31n = 30n + n > 30n+8$, so $30n+8 < cn$.

iii. Show that $100n + 5 \neq \Omega(n2)$
$\exists$ c, n0 such that: $0 \leq cn2 \leq 100n + 5$
$100n + 5 \leq 100n + 5n \ (\forall\ n \geq 1) = 105n$
$cn2 \leq 105n \Rightarrow n(cn - 105) \leq 0$
Since n is positive $\Rightarrow cn - 105 \leq 0 \Rightarrow n \leq 105/c$
$\Rightarrow$contradiction: n cannot be smaller than a constant

d. O(log n), O(n), O(n log n) , $O(n^2)$, $O(n^3)$,$O(2^n)$ (2 marks)

2a. Definition = 2 marks Adv & Disadv = 2 marks Examples = 1 mark

Divide-and-conquer is a top-down technique for designing algorithms that consists of dividing the problem into smaller sub problems hoping that the solutions of the sub problems are easier to find and then composing the partial solutions into the solution of the original problem.

Divide-and-conquer paradigm consists of following major phases:

- Breaking the problem into several sub-problems that are similar to the original problem but smaller in size,
- Solve the sub-problem recursively (successively and independently), and then
- Combine these solutions to sub problems to create a solution to the original problem.

Advantages	Disadvantages
Solving difficult problems	Conceptual difficulty
Algorithm efficiency	Recursion overhead
Parallelism	Repeated sub problems
Memory access	
Roundoff control	

Examples of its application in well-known algorithms include; Binary search, Powering a number, Matrix multiplication, merge sort and heap sort.

b. What is the general divide and conquer recurrence relation?
Time efficiency T(n) of many divide and conquer algorithms satisfies the equation $T(n) = a.T(n/b) + f(n)$. This is the general recurrence relation.
Where a = no of sub problems, b = size of sub problems and f(n) = costs of the divide and combine operations. ($2^1/_2$ marks)

c. Analysis of Strassen's Algorithm 4 marks
$T(n) = 7 * T(n/2) + \Theta(n^2)$
$n^{\log_b a}$ a=7,b=2
$=n^{lg7}$

case 1 of Master theorem

$T(n) = \Theta(n^{lg7}) = O(n^{2.81})$

d. 6 marks

The recursive relation is

$T(n) = 2T(n/2) + M(n)$, where $M(n)$ is linear in n.

Using Master's Theorem

$T(n) \in O(n^{\log_b a})$ if $a > b^c$

$T(n) \in O(n^c \log n)$ if $a = b^c$

$T(n) \in O(n^c)$ if $a < b^c$

Solution: a = 2, b = 2, c = 1 → $a = b^c$ → Case 2

Hence $T(n) \in O(n \log n)$

3 a. Recursion is the process of defining a problem (or the solution to a problem) in terms of (a simpler version of) itself. An algorithm is said to be recursive if the same algorithm is invoked in the body.

Recursion occurs where the definition of an entity refers to the entity itself. Recursion can be direct when an entity refers to itself directly or indirect when it refers to other entities which refers to it. A (Directly) recursive routine calls itself. Mutually recursive routines are an example of indirect recursion. A (Directly) recursive data type contains pointers to instances of the data type. (3 marks)

b. The Fibonacci algorithm is given below; (2½ marks)

```
long fibonacci (int n) {
      if( n == 1 || n == 2)
            return 1;
      else
            return fibonacci(n - 1) + fibonacci(n - 2);
}
```

c. (6 marks)

Tower of Hanoi is a puzzle that consists of three pegs and five disks. Figure 1 shows the starting position of the puzzle. The goal is to reposition the stack of disks from peg A to peg C by moving one disk at a time, and, never placing a larger disk on top of a smaller disk.

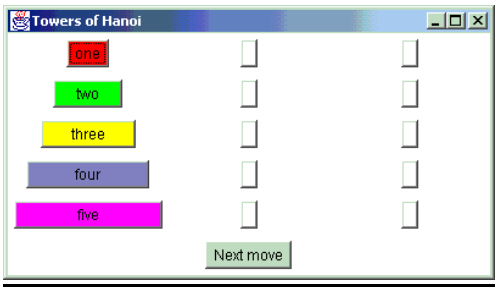


Figure 1

The algorithm for solving the puzzle is given by:

```
Tower_Of_Hanoi(N, source, destination, helper):
    If N==1:
        Move disk from source to destination
    Else:
        Tower_Of_Hanoi (N-1, source, destination, helper)
        Move disk from source to destination
        Tower_Of_Hanoi (N-1, helper, destination, source)
```

The recurrence relation is

$T(n) = a$ if $n = 1$

$T(n) = 2T(n - 1) + b$ if $n > 1$

$T(n) \varepsilon \mathbf{O(2^n)}$

d. (6 marks)

The time complexity of the Parallel-Product algorithm can be expressed as

```
T(n) =  T(n/2) + O(n/2)
T(1) = 1
```

We can solve it as:

```
T(n) =  T(n/2) + O(n/2)
     =  (T(n/2^2) + O(n/2^2)) + O(n/2)
     =  T(n/2^2) + O(n/2^2) + O(n/2)
     =  T(n/2^3) + O(n/2^3) + O(n/2^2) + O(n/2)
        ...
     =  T(n/2^i) + O(n/2^i) +...+  O(n/2^2) + O(n/2)
     =  T(n/2^log n) + O(n/2^log n) +...+  O(n/2^2) + O(n/2)
              // We stop the expansion at i = log n because
                 2^log n =  n //
     =  T(1) + O(n/2^log n) +...+  O(n/2^2) + O(n/2)
     =  1 + O(n/2^log n +...+  n/2^2 + n/2)
     =  1 + O(n*(1/2^log n +...+  1/2^2 + 1/2)
     =  O(n)
```

4a. Analysis of the linear search algorithm

This is O(n) in the worst case and Ω (1) in the best case.

If the elements of an array A are distinct and query point q is indeed in the array then loop executed (n + 1) / 2 average number of times. On average (as well as the worst case), sequential search takes θ(n) time.

b.

i. Yes, the binary search algorithm is an improvement over the sequential search algorithm. This is because it employs the Divide and Conquer approach which explains why it has increased efficiency.

ii. Condition for best case – the element is the first element in the array

average case – the element is the middle element in the array
worst case – the element is the last element in the array

c.

c. Algorithm 1

. Recurrence equation

$T(n) = T(n/2) + \Theta(1)$

Using Master Theorem

a=1, b=2

$n^{\log_b a} = n^0 = 1$

case 2(k=0)

$T(n) = \Theta(\lg n)$ 4 marks

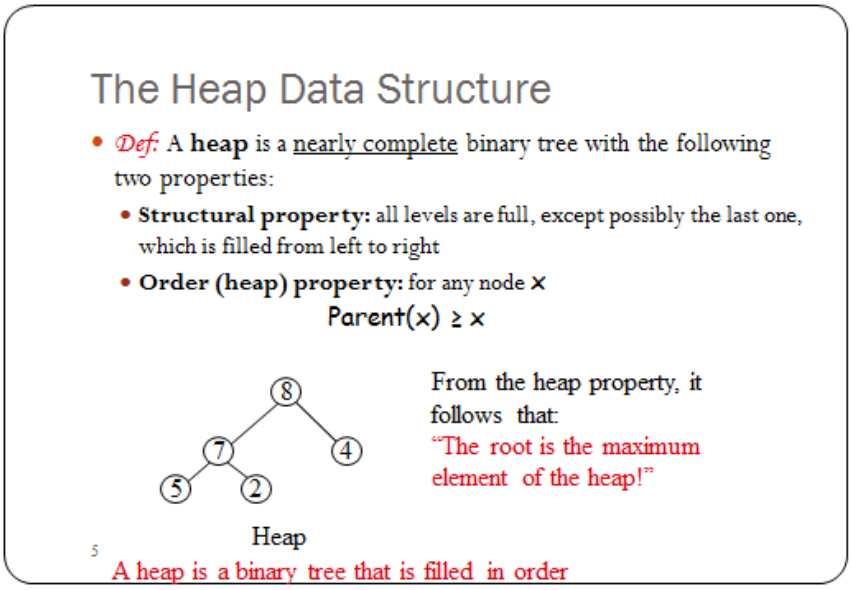
Algorithm 2

The major operation in the algorithm is the for loop as other operation are O(1). The for loop will be executed n times. The algorithm is O(n). $2^1/_2$ marks

Therefore Algorithm 1 is more time efficient 1mark

d. Algorithm 1 employs the Divide and Conquer approach which explains why it has increased efficiency over the iterative version in Algorithm 2. 2 marks

5a. ($2^1/_2$ marks)



b. (5 marks)

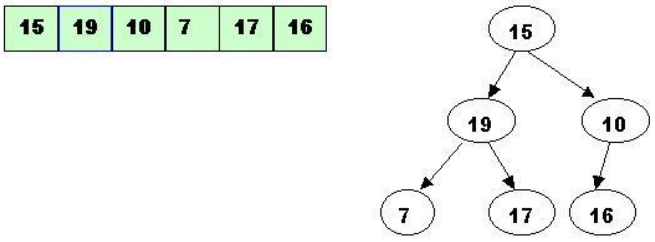
We can perform the following operations on heaps:

- MAX-HEAPIFY O(lgn)
- BUILD-MAX-HEAP O(n)
- HEAP-SORT O(nlgn)
- MAX-HEAP-INSERT O(lgn)
- HEAP-EXTRACT-MAX O(lgn)

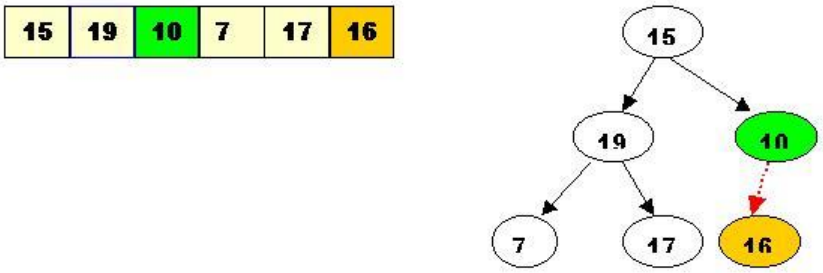
c. (7 marks)

A. Building the heap tree

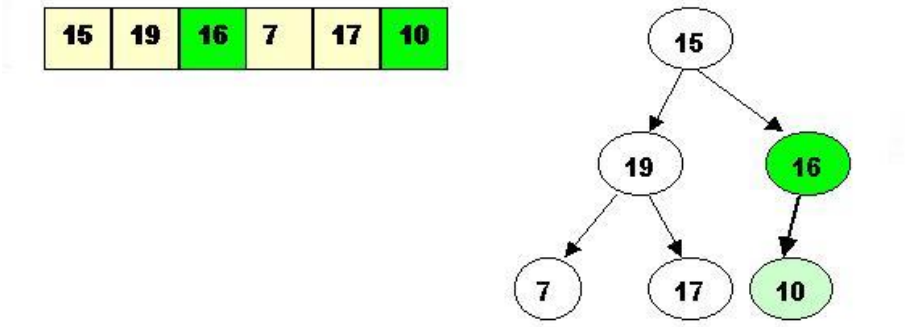
The array represented as a tree, complete but not ordered:



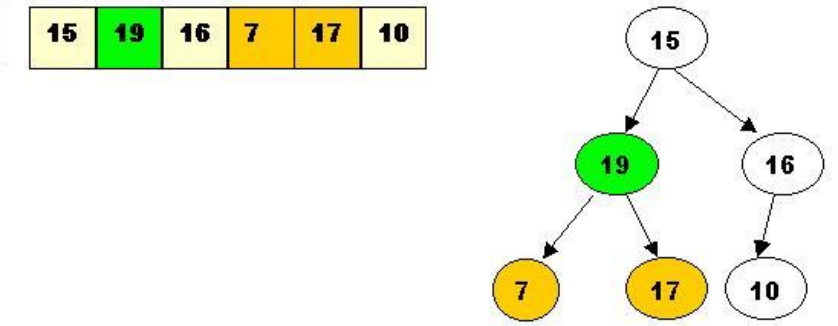
Start with the rightmost node at height 1 - the node at position 3 = Size/2.
It has one greater child and has to be percolated down:



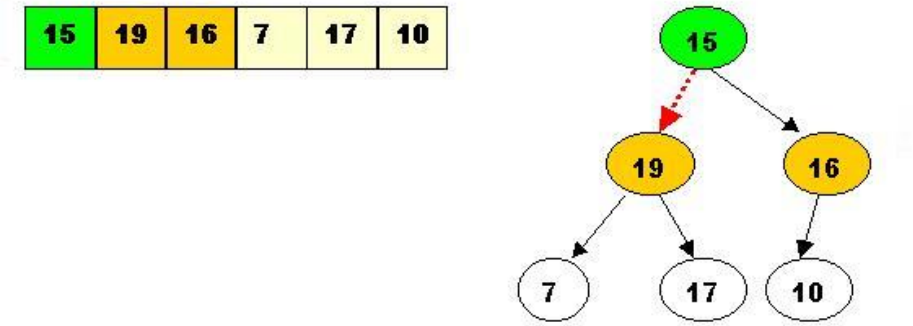
After processing array[3] the situation is:



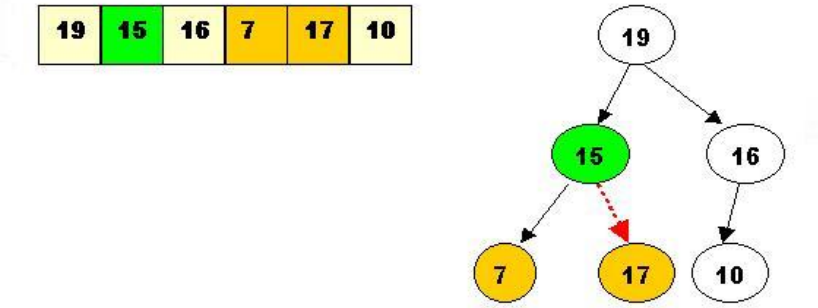
Next comes array[2]. Its children are smaller, so no percolation is needed.



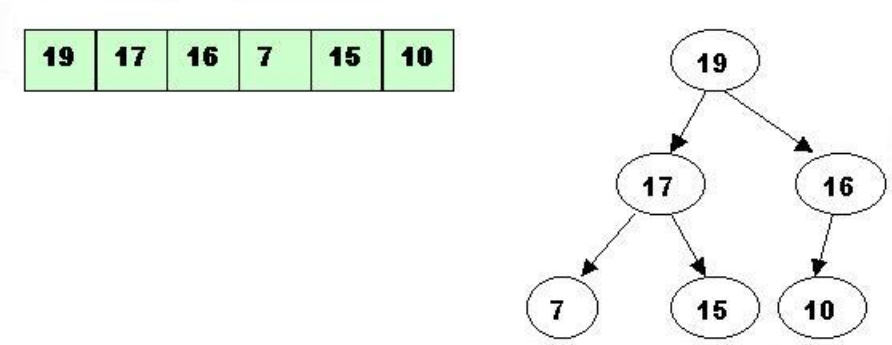
The last node to be processed is array[1]. Its left child is the greater of the children.
The item at array[1] has to be percolated down to the left, swapped with array[2].



As a result the situation is:

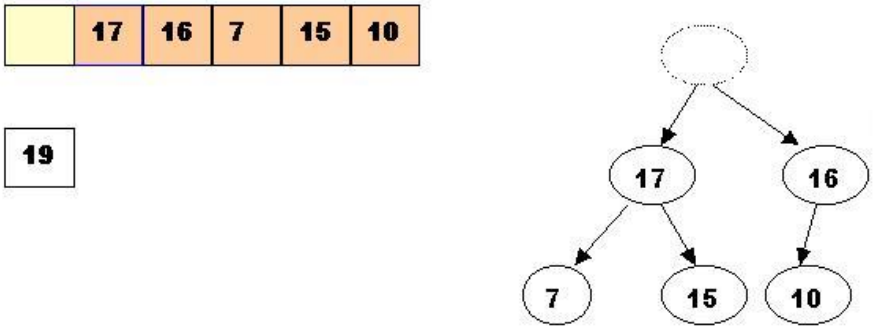


The children of array[2] are greater, and item 15 has to be moved down further, swapped with array[5].



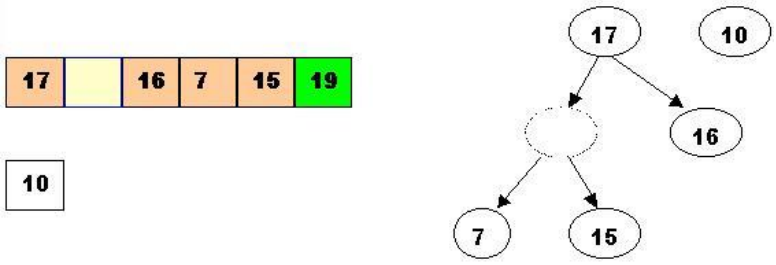
B. Sorting - performing deleteMax operations:
1. Delete the top element 19.

1.1. Store 19 in a temporary place. A hole is created at the top

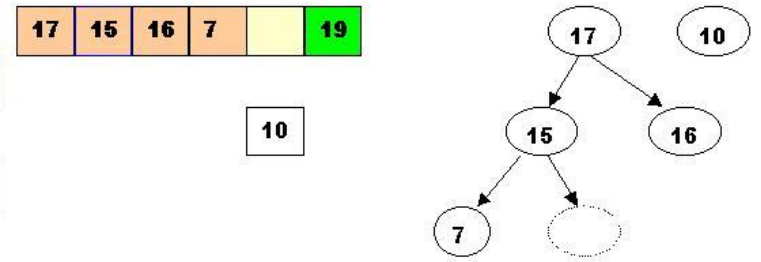


1.2. Swap 19 with the last element of the heap.
As 10 will be adjusted in the heap, its cell will no longer be a part of the heap.
Instead it becomes a cell from the sorted array

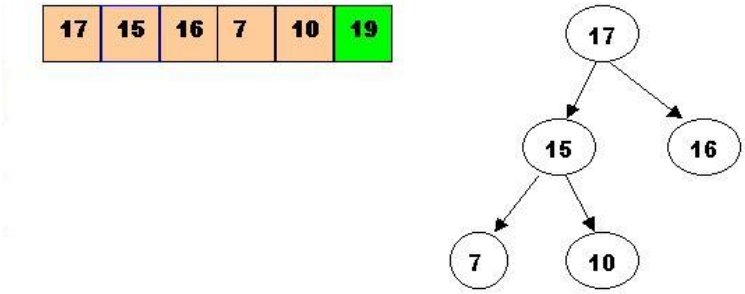
1.3. Percolate down the hole



1.4. Percolate once more (10 is less that 15, so it cannot be inserted in the previous hole)

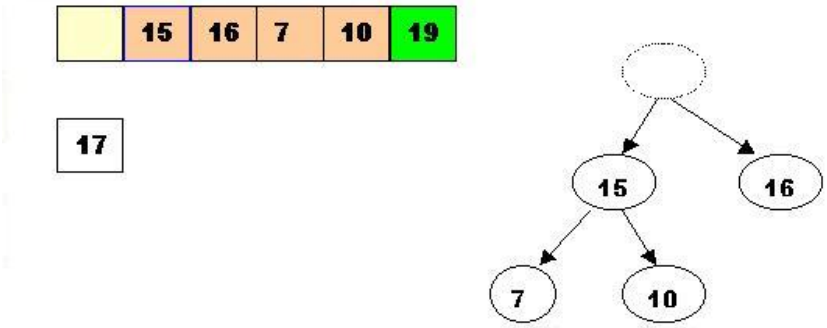


Now 10 can be inserted in the hole

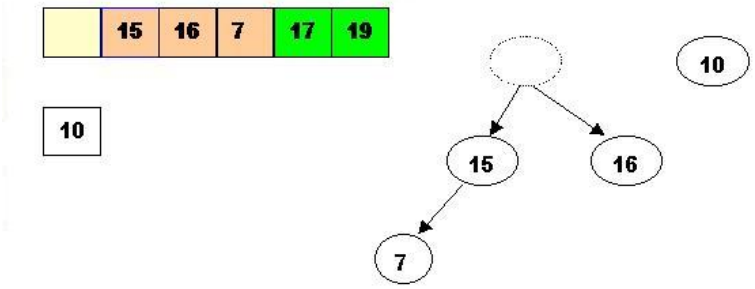


2. DeleteMax the top element 17

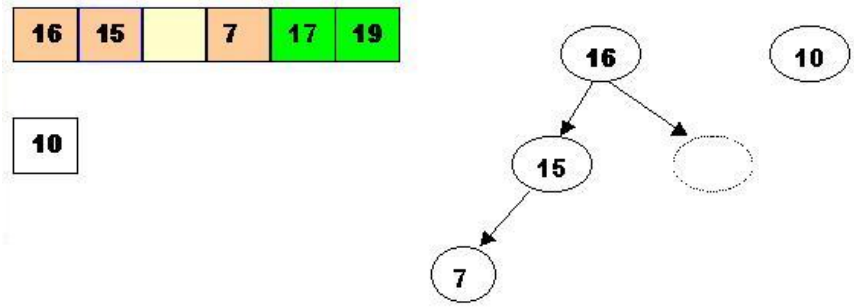
2.1. Store 17 in a temporary place. A hole is created at the top



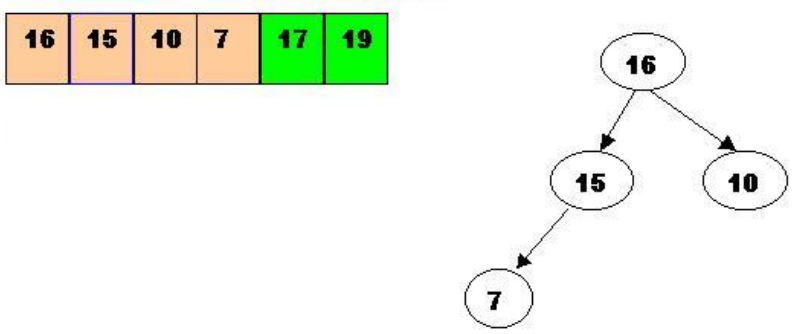
2.2. Swap 17 with the last element of the heap.
As 10 will be adjusted in the heap, its cell will no longer be a part of the heap.
Instead it becomes a cell from the sorted array



2.3. The element 10 is less than the children of the hole, and we percolate the hole down:

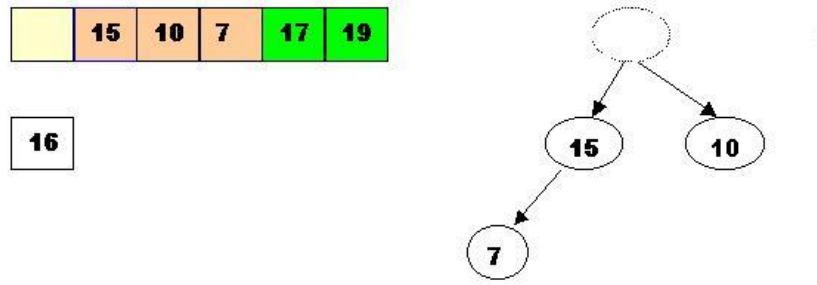


2.4. Insert 10 in the hole



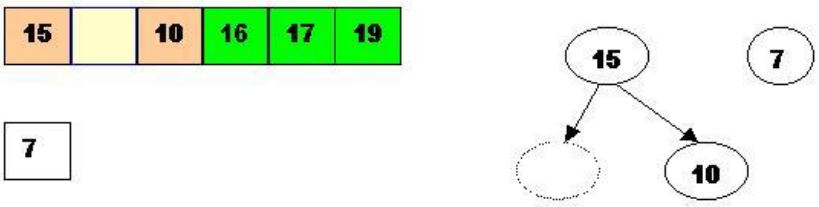
3. DeleteMax 16

3.1. Store 16 in a temporary place. A hole is created at the top



3.2. Swap 16 with the last element of the heap.
As 7 will be adjusted in the heap, its cell will no longer be a part of the heap.
Instead it becomes a cell from the sorted array

3.3. Percolate the hole down (7 cannot be inserted there - it is less than the children of the hole)

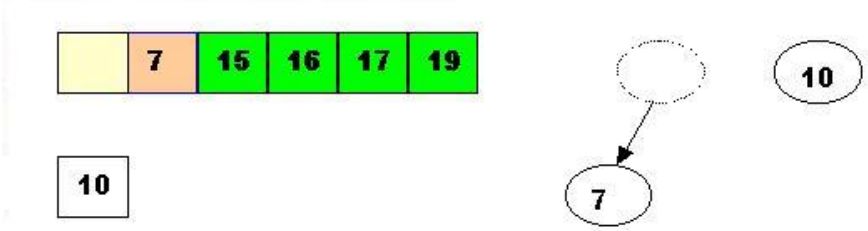


3.4. Insert 7 in the hole

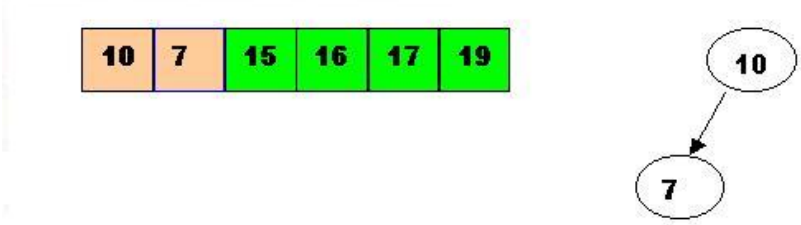
4. DeleteMax the top element 15

4.1. Store 15 in a temporary location. A hole is created.

4.2. Swap 15 with the last element of the heap.
As 10 will be adjusted in the heap, its cell will no longer be a part of the heap.
Instead it becomes a position from the sorted array



4.3. Store 10 in the hole (10 is greater than the children of the hole)



5. DeleteMax the top element 10.
5.1. Remove 10 from the heap and store it into a temporary location.

5.2. Swap 10 with the last element of the heap.
As 7 will be adjusted in the heap, its cell will no longer be a part of the heap. Instead it becomes a cell from the sorted array

5.3. Store 7 in the hole (as the only remaining element in the heap

7 is the last element from the heap, so now the array is sorted

d. (3 marks)

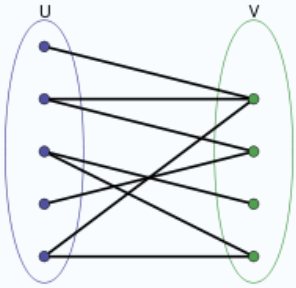
Name	Worst Case	Stable	Method
Bubble Sort	$\mathcal{O}\left(n^2\right)$	Yes	Exchanging
Selection Sort	$\mathcal{O}\left(n^2\right)$	No	Selection
Insertion Sort	$\mathcal{O}\left(n^2\right)$	Yes	Insertion
Merge Sort	$\mathcal{O}\left(n \log n\right)$	Yes	Merging
Heap Sort	$\mathcal{O}\left(n \log n\right)$	No	Selection

6.

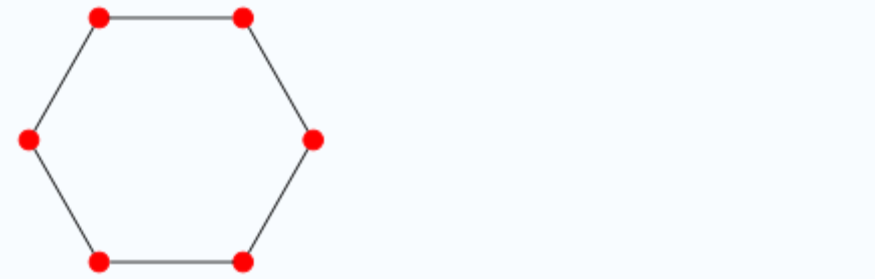
a) I mark each = 7 marks

i. a **path** in a graph is a sequence of vertices such that from each of its vertices there is an edge to the next vertex in the sequence.

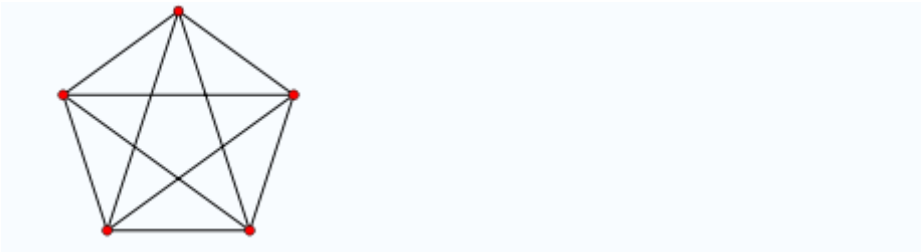
ii. a **bipartite graph** (or **bigraph**) is a graph whose vertices can be divided into two disjoint sets *U* and *V* such that every edge connects a vertex in *U* to one in *V*; that is, *U* and *V* are independent sets.



iii. A **cycle** is a path such that the start vertex and end vertex are the same.



iv. In a **complete graph** each pair of vertices is joined by an edge, that is, the graph contains all possible edges.



v. A **directed graph** or **digraph** is an ordered pair $D = (V, A)$ with V a set whose elements are called **vertices** or **nodes**, and A a set of ordered pairs of vertices, called **arcs**, **directed edges**, or **arrows**.

vi. A graph is a **weighted graph** if a number (weight) is assigned to each edge. Such weights might represent, for example, costs, lengths or capacities, etc. depending on the problem.

vii. a spanning tree of that graph is a subgraph which is a tree and connects all the vertices together. A single graph can have many different spanning trees. A **minimum spanning tree** (MST) is then a spanning tree with weight less than or equal to the weight of every other spanning tree

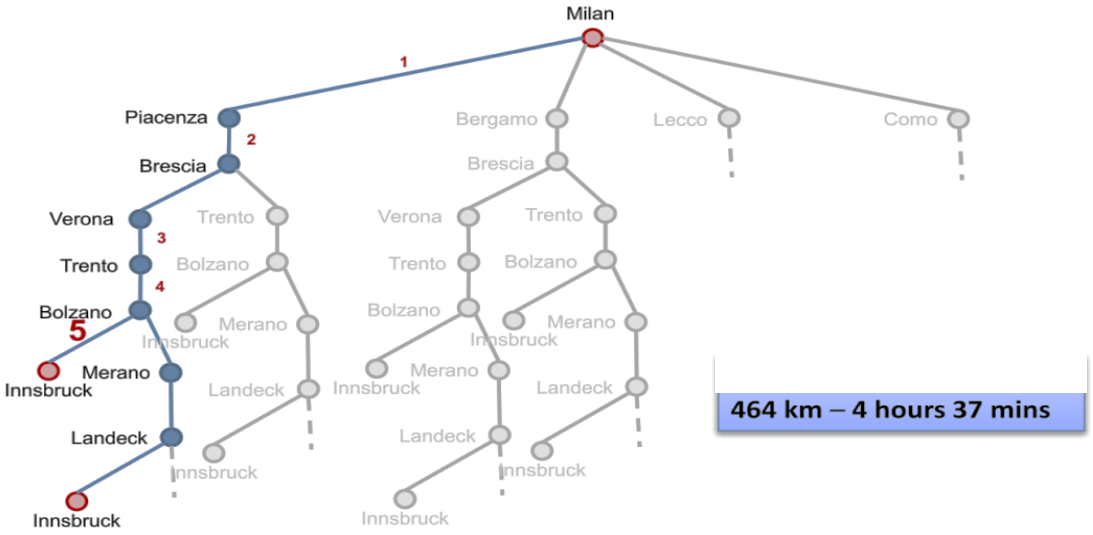
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**0**
2	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**1**

b)

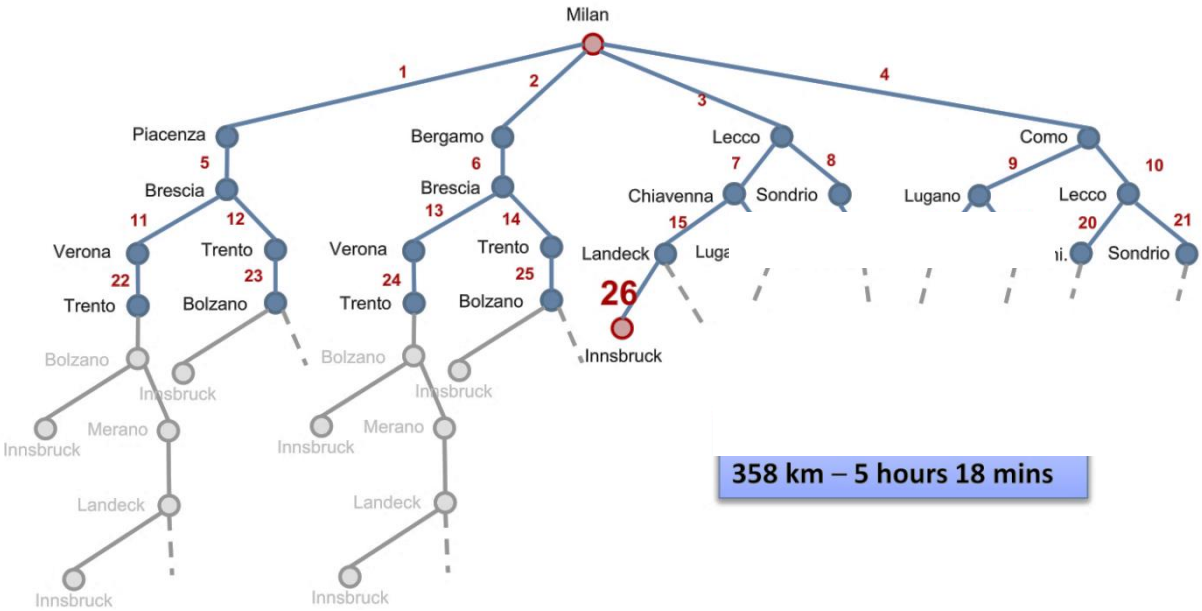
3	**0**	**1**	**1**	**0**	**0**	**1**	**0**	**0**
4	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**0**
5	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**1**

(2½ marks)

c) (3 marks)



d) (5 marks)



COVENANT UNIVERSITY

CANAANLAND, KM 10, IDIROKO ROAD
P.M.B 1023, OTA, OGUN STATE, NIGERIA.

TITLE OF EXAMINATION: B.Sc EXAMINATION
COLLEGE: College of Science and Technology
SCHOOL: School of Natural & Applied Sciences
DEPARTMENT: Department of Computer and Information Sciences
SESSION: 2014/2015 **SEMESTER:** ALPHA
COURSE CODE: CSC 413 **CREDIT UNIT:** 3
COURSE TITLE: Algorithm & Complexity Analysis
INSTRUCTION: Answer ANY 4 questions **TIME**: 3 HOURS

---

1. (a) Write short notes on the following
   v. Time Complexity
   vi. Space Complexity
   vii. Best, worst, average case of an algorithm
   viii. Correct / In-correct algorithm (3½marks)

   (b) Express functions in A in asymptotic notation using functions in B.

	A	B
i.	$5n^2 + 100n$	$3n^2 + 2$
ii.	$\log_3(n^2)$	$\log_2(n^3)$
iii.	$n^{\lg 4}$	$3^{\lg n}$
iv.	$\lg^2 n$	$n^{1/2}$

   (4 marks)

   (c) Give the formal definition for the five asymptotic notations and summarize these asymptotic notations in a Venn diagram (6 marks)

   (d) What are algorithm design techniques? (4 marks)

2. (a). List the complexity classes in ascending order. (4 marks)

   (b) i. Prove that if $f(n) = 15n^3 + n^2 + 4$, $f(n) = O(n^3)$
   ii. Show that $30n+8$ is $O(n)$.
   iii. Show that $100n + 5 \neq \Omega(n2)$ (3 marks)

   (c) Consider the program with n nested loops below which checks all possible truth assignments to the n Boolean variables for the function f( ) and computes the number of times it is true. What is its running time? (2½ marks)

```
sat = 0
 for X1 = true, false do
      for X2 = true, false do
             .
             .
             .
         for Xn = true, false, do
          if (f(X1, X2, ... , Xn) = true)
           then sat = sat+1
```

(d) Find the time complexity of the following loop segments. (8 marks)

i.
```
for ( int i = 0; i < n; i++ ) {
      for ( int j = 0; j < 3; j++ ) {
            // some O(1) expressions
      }
}
```

ii.
```
// Here c is a constant greater than 1
for (int i = 2; i <=n; i = pow(i, c)) {
      // some O(1) expressions
}
```

iii.
```
for ( int i = 0; i < n; i++ ) {
      for ( int j = 0; j < i; j++ ) {
            // some O(1) expressions
      }
}
```

iv.
```
for (int i = 1; i <= m; i += c) {
      // some O(1) expressions
}
for (int i = 1; i <= n; i += c) {
      // some O(1) expressions
}
```

3. (a) Define the concept "Divide and Conquer". State its advantages and disadvantages. (5 marks)

(b) What is the general divide and conquer recurrence relation? ($2^1/_2$ marks)

(c) Strassen's algorithm shows how to multiply two n by n matrices by multiplying 7 pairs of n/2 by n/2 matrices, and then doing n^2 operations to combine them. What is the running time of the Strassen's matrix multiplication algorithm (5 marks)

(d) Comment briefly on the merge sort algorithm. Hence, describe its recurrence relation. (5 marks)

4. (a) What are recursive algorithms? Differentiate between direct and indirect recursive algorithms. (5 marks)

(b) Write a recursive algorithm for computing the factorial function F(n) = n! for an arbitrary non negative integer n. ($2^1/_2$ marks)

(c) Given the Fibonacci algorithm below;

```
long fibonacci (int n) {
      if( n == 1 || n == 2)
            return 1;
      else
            return fibonacci(n - 1) + fibonacci(n - 2);
```

```
}
```

i. State its recurrence equation

ii. Hence, find its running time using the characteristics equation. (5 marks)

(d) Tower of Hanoi is a puzzle that consists of three pegs and five disks. Figure 1 shows the starting position of the puzzle. The goal is to reposition the stack of disks from peg A to peg C by moving one disk at a time, and, never placing a larger disk on top of a smaller disk. Show that this problem can be solved in $O(2^n)$ time. (5 marks)

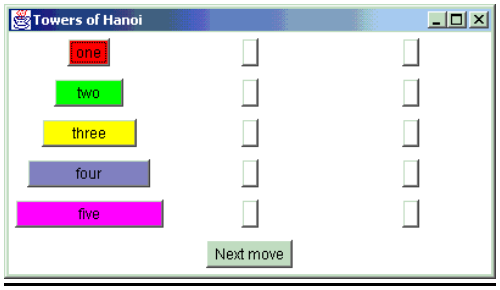


Figure 1

5. (a) State the worst case, best case and average case of the sequential search algorithm below.

```
for i = 1 to n do
       if A [i] ≥ q then
                    return index i
      return n + 1
```

(3 marks)

(b) Given the Binary search algorithm below;

```
public int binarySearch (int target,int[] array, int low, int high)
{
      if (low > high)
         return -1;
      else {
         int middle = (low + high)/2;
         if (array[middle] == target)
            return middle;
         else if(array[middle] < target)
            return binarySearch(target, array, middle + 1, high);
         else
            return binarySearch(target, array, low, middle - 1);
        }
}
```

iii. Is it an improvement over the sequential search algorithm in 5a above? Give reasons for your answer.

iv. Comment on the conditions for the best case, average case and worst case of the binary search algorithm. (5 marks)

(c) Write an efficient algorithm for computing x raised to the power of y. (4 marks)

(d) Sort the following numbers in ascending order using Insertion Sort

{18, 6, 9, 1, 4, 15, 12, 5, 6, 7, 11} (5½marks)

6. (a) Define the sorting problem. (1½marks)

(b) Write short notes on the following. (4 marks)

i. Internal sort

ii. External sort

iii. In Place sort

iv. Stable sort

(c) Calculate the worst case and best case of the quick sort algorithm below? (6 marks)

```
quicksort(A, i, k):
    if i < k:
      p := partition(A, i, k)
      quicksort(A, i, p - 1)
      quicksort(A, p + 1, k)
```

Hint: the time to build the partition is linear.

(d) Complete the table below. (6 marks)

Name	Average Case	Worst Case	Memory	Stable	Method
Bubble Sort					
Selection Sort					
Insertion Sort					
Shell Sort					
Merge Sort					
Heap Sort					

MARKING SCHEME

1a. Write short notes on the following $^1/_2$ mark each = $3^1/_2$ marks

v. Time Complexity - the time complexity of an algorithm quantifies the amount of time taken by an algorithm to run as a function of the input size.

vi. Space Complexity of an algorithm is total space taken by the algorithm with respect to the input size.

vii. Worst case

Provides an upper bound on running time

An absolute guarantee that the algorithm would not run longer, no matter what the inputs are

Best case

Provides a lower bound on running time

Input is the one for which the algorithm runs the fastest

Average case

Provides a prediction about the running time

Assumes that the input is random

The running time for any given size input will be the average number of operations over all problem instances for a given size.

viii. An algorithm is said to be correct if, for every input instance, it halts with the correct output. We then say that a correct algorithm solves the given computational problem.

An incorrect algorithm might not halt at all on some input instances or it might halt with an answer other than the desired one.

b. Express functions in A in asymptotic notation using functions in B.

	A	B	
i.	$5n^2 + 100n$	$3n^2 + 2$	1 mark

$A \in \Theta(n^2)$, $n^2 \in \Theta(B) \Rightarrow$ **$A \in \Theta(B)$**

ii.	$\log_3(n^2)$	$\log_2(n^3)$	1 mark

$\log_b a = \log_c a / \log_c b$; $A = 2\lg n / \lg 3$, $B = 3\lg n$, $A/B = 2/(3\lg 3) \Rightarrow$ **$A \in \Theta(B)$**

iii.	$n^{\lg 4}$	$3^{\lg n}$	1 mark

$a^{\log b} = b^{\log a}$; $B = 3^{\lg n} = n^{\lg 3}$; $A/B = n^{\lg(4/3)} \to \infty$ as $n \to \infty$

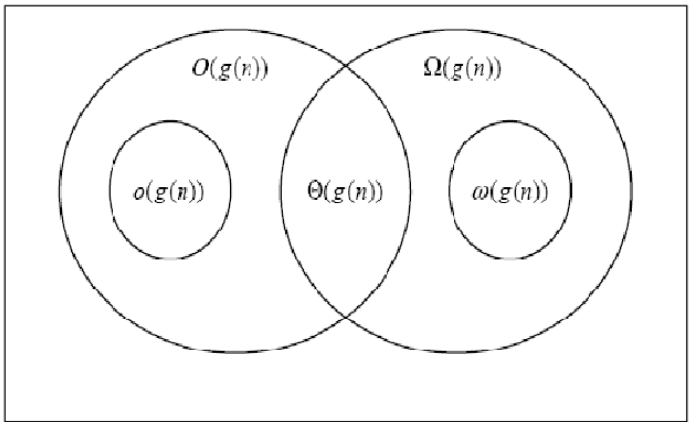
$\Rightarrow$ **$A \in \omega (B)$**

iv.	$\lg^2 n$	$n^{1/2}$	1 mark

$\lim (\lg^a n / n^b) = 0$ (here $a = 2$ and $b = 1/2$) $\Rightarrow$ **$A \in o (B)$**

c.

O-notation (upper bounds):
$O(g(n))$= { f(n) : there exist constants c>0, n_0>0 such that $0 \le f(n) \le cg(n)$for all $n \ge n_0$}
Ω-notation (lower bounds)
$\Omega(g(n))$= { $f(n)$:there exist constants c>0, n_0>0 such that $0 \le cg(n) \le f(n)$ for all $n \ge n_0$}
Θ-notation (tight bounds)
$\Theta(g(n)) = O(g(n)) \cap \Omega(g(n))$
o-notation
$o(g(n))$= { $f(n)$:for any constant c>0, there is a constant n_0>0 such that $0 \le f(n) < cg(n)$ for all $n \ge n_0$}
ω-notation
$\omega(g(n))$= { $f(n)$:for any constant c> 0, there is a constant n_0>0 such that $0 \le cg(n) < f(n)$ for all $n \ge n_0$}



d. Algorithm design techniques (or strategies or paradigms) are general approaches to solving problems algorithmically, applicable to a variety of problems from different areas of computing. General design techniques are:

(i) Brute force (ii) Divide and conquer (iii) Decrease and conquer
(iv) Transform and conquer (v) Greedy technique (vi) Dynamic programming
(vii) Backtracking (viii) Branch and bound 4 marks

2a.

T(n)	Name	Problems
O(1)	constant	Easy-solved
O(logn)	logarithmic	
O(n)	linear	
O(nlogn)	Linear-logarithmic	
$O(n^2)$	quadratic	
$O(n^3)$	cubic	
O(2n)	exponential	Hard-solved
O(n!)	factorial	

b. i. Proof.

Let $c_1 = 15$, $c_2 = 20$ and $n_0 = 1$.
Must show that $c_1g(n) \leq f(n)$ and $f(n) \leq c_2g(n)$.
$c_1g(n) = 15n^3 \leq 15n^3 + n^2 + 4 = f(n)$.
$f(n) = 15n^3 + n^2 + 4 \leq 15n^3 + n^3 + 4n^3 = 20n^3 = c_2g(n)$

ii. Show $\exists$ c, n0: $30n+8 \leq cn$, $\forall n>n0$.

Let c=31, n0=8. Assume n>n0=8. Then
$cn = 31n = 30n + n > 30n+8$, so $30n+8 < cn$.

iii. Show that $100n + 5 \neq \Omega(n2)$

$\exists$ c, n0 such that: $0 \leq cn2 \leq 100n + 5$
$100n + 5 \leq 100n + 5n$ ($\forall n \geq 1$) $= 105n$
$cn2 \leq 105n \Rightarrow n(cn - 105) \leq 0$
Since n is positive $\Rightarrow cn - 105 \leq 0 \Rightarrow n \leq 105/c$
$\Rightarrow$contradiction: n cannot be smaller than a constant

c. To determine the complexity we must find out exactly how many times the function is evaluated. Recalling that since we are dealing with nested loops, we multiply together the number of times each of the loops is executed. Since each loop is executed twice, this is:

$2(2(2(. . . (2(2)) . . .))) = 2*2*2* . . . * 2*2 = 2^n$.

Thus the complexity of the algorithm is $O(2^n)$.

d. Find the time complexity of the following loop segments. 8 marks (2 marks each)

i. The inner loop will execute exactly 3 times for each of the n iterations of the outer loop, and so the total number of times the statements in the innermost loop will be executed is 3n or O(n) times

ii. Time Complexity of the loop is O(LogLogn) because the loop variables is increased exponentially by a constant amount.

iii. On the 1st iteration of the outer loop (i = 0), the inner loop will iterate 0 times
On the 2nd iteration of the outer loop (i = 1), the inner loop will iterate 1 time
On the 3rd iteration of the outer loop (i = 2), the inner loop will iterate 2 times
.
.
On the FINAL iteration of the outer loop (i = n - 1), the inner loop will iterate n - 1 times
So, the total number of times the statements in the inner loop will be executed will be equal to the sum of the integers from 1 to n - 1, which is:
$((n - 1)*n) / 2 = n^2/2 - n/2 = O(n^2)$ times

iv. Time complexity is O(m) + O(n) which is O(m+n)

3a. Divide-and-conquer is a top-down technique for designing algorithms that consists of dividing the problem into smaller sub problems hoping that the solutions of the sub problems are easier to find and then composing the partial solutions into the solution of the original problem.

Divide-and-conquer paradigm consists of following major phases:

- Breaking the problem into several sub-problems that are similar to the original problem but smaller in size,
- Solve the sub-problem recursively (successively and independently), and then
- Combine these solutions to sub problems to create a solution to the original problem.

Advantages	Disadvantages
Solving difficult problems	Conceptual difficulty
Algorithm efficiency	Recursion overhead
Parallelism	Repeated sub problems
Memory access	
Roundoff control	

b. What is the general divide and conquer recurrence relation?

Time efficiency T(n) of many divide and conquer algorithms satisfies the equation $T(n) = a.T(n/b) + f(n)$. This is the general recurrence relation.

Where a = no of sub problems, b = size of sub problems and f(n) = costs of the divide and combine operations.

c. Analysis of Strassen's Algorithm

$T(n) = 7 * T(n/2) + \Theta(n^2)$

$n^{\log_b a}$ a=7,b=2

$=n^{lg7}$

case 1 of Master theorem

$T(n) = \Theta(n^{lg7}) = O(n^{2.81})$

d. Merge sort is divide and conquer strategy that works by dividing an input array in to two halves,sorting them recursively and then merging the two sorted halves to get the original array sorted

$$T(n) = \begin{cases} a, & n = 1 \\ 2T\left(\frac{n}{2}\right) + n, & n > 1 \end{cases}$$

4. a. An algorithm is said to be recursive if the same algorithm is invoked in the body. Recursion occurs where the definition of an entity refers to the entity itself. Recursion can be direct when an entity refers to itself directly or indirect when it refers to other entities which refers to it. A (Directly) recursive routine calls itself. Mutually recursive routines are an example of indirect recursion. A (Directly) recursive data type contains pointers to instances of the data type.

b.
```
long factorial (int n) {
        if (n == 0)
                return 1;
        else
                return n * factorial (n – 1);
}
```

c. Analysis of the Fibonacci algorithm

Solution: The Fibonacci numbers satisfy the recurrence relation $f_n = f_{n-1} + f_{n-2}$ with initial conditions $f_0 = 0$ and $f_1 = 1$.

The characteristic equation is $r^2 – r – 1 = 0$.

Its roots are

$$r_1 = \frac{1+\sqrt{5}}{2}, \quad r_2 = \frac{1-\sqrt{5}}{2}$$

Therefore, the Fibonacci numbers are given by

$$f_n = \alpha_1\left(\frac{1+\sqrt{5}}{2}\right)^n + \alpha_2\left(\frac{1-\sqrt{5}}{2}\right)^n$$

for some constants α_1 and α_2.

We can determine values for these constants so that the sequence meets the conditions $f_0 = 0$ and $f_1 = 1$:

$$f_0 = \alpha_1 + \alpha_2 = 0$$

$$f_1 = \alpha_1\left(\frac{1+\sqrt{5}}{2}\right) + \alpha_2\left(\frac{1-\sqrt{5}}{2}\right) = 1$$

1^

The unique solution to this system of two equations and two variables is

$$\alpha_1 = \frac{1}{\sqrt{5}}, \quad \alpha_2 = -\frac{1}{\sqrt{5}}$$

So finally we obtained an explicit formula for the Fibonacci numbers:

$$f_n = \frac{1}{\sqrt{5}}\left(\frac{1+\sqrt{5}}{2}\right)^n - \frac{1}{\sqrt{5}}\left(\frac{1-\sqrt{5}}{2}\right)^n$$

Therefore, Recursive Fibonacci algorithm is $O(2^n)$
i.e. Recursive Fibonacci is exponential

d.
Analysis of towers for Hanoi problem

The recursive relation is

$T(n) = a$ if $n = 1$
$T(n) = 2T(n - 1) + b$ if $n > 1$

$= 2[2T(n-2) + b] + b = 2^2 T(n-2) + 2b + b$ by substituting $T(n-1)$
$= 2^2 [2T(n-3) + b] + 2b + b = 2^3 T(n-3) + 2^2 b + 2b + b$ by substituting $T(n-2)$
$= 2^3 [2T(n-4) + b] + 2^2 b + 2b + b = 2^4 T(n-4) + 2^3 b + 2^2 b + 2^1 b + 2^0 b$ by substituting $T(n-3)$ in (2)
$= \ldots\ldots$
$= 2^k T(n-k) + b[2^{k-1} + 2^{k-2} + \ldots 2^1 + 2^0]$

$$= 2^k T(n-k) + b\sum_{i=0}^{k-1} 2^i$$

$$= 2^k T(n-k) + b(2^k - 1)$$

The base case is reached when $n - k = 1 \rightarrow k = n - 1$, we then have:

$$T(n) = 2^{n-1} T(1) + b(2^{n-1} - 1)$$

$$= (a + b)\, 2^{n-1} - b$$

$$= \left(\frac{a+b}{2}\right) 2^n - b$$

Hence T(n) ε **$O(2^n)$**

5a. Analysis of the linear search algorithm

This is O(n) in the worst case and Ω (1) in the best case.

If the elements of an array A are distinct and query point q is indeed in the array then loop executed (n + 1) / 2 average number of times. On average (as well as the worst case), sequential search takes θ(n) time.

b.

i. Yes, the binary search algorithm is an improvement over the sequential search algorithm. This is because it employs the Divide and Conquer approach which explains why it has increased efficiency.

ii. Condition for best case – the element is the first element in the array
average case – the element is the middle element in the array
worst case – the element is the last element in the array

c. Algorithm 1

```
long powerA (int x, unsigned int n)
{
   int temp;
   if( n == 0)
      return 1;
   temp = power(x, n/2);
   if (n%2 == 0)
      return temp*temp;
   else
      return x*temp*temp;
}
```

Algorithm 2

```
long powerB (int x, unsigned int n)
{
     long prod = 1;
     if( n == 0)
          return prod;
     for(i=1; i <= n; i++)
          prod *= x
     return prod
}
```

d.

{**18**, 6, 9, 1, 4, 15, 12, 5, 6, 7, 11}
{ **6**, 18, 9, 1, 4, 15, 12, 5, 6, 7, 11}
{ 6, **9**, 18, 1, 4, 15, 12, 5, 6, 7, 11}
{ **1**, 6, 9, 18, 4, 15, 12, 5, 6, 7, 11}
{ 1, **4**, 6, 9, 18, 15, 12, 5, 6, 7, 11}
{ 1, 4, 6, 9, **15**, 18, 12, 5, 6, 7, 11}
{ 1, 4, 6, 9, **12**, 15, 18, 5, 6, 7, 11}
{ 1, 4, **5**, 6, 9, 12, 15, 18, 6, 7, 11}
{ 1, 4, 5, 6, **6**, 9, 12, 15, 18, 7, 11}
{ 1, 4, 5, 6, 6, **7**, 9, 12, 15, 18, 11}
{ 1, 4, 5, 6, 6, 7, 9, **11**, 12, 15, 18}

6a. The sorting problem

Input:

- A sequence of n numbers $a_1, a_2, \ldots, a_n$

Output:

- A permutation (reordering) $a_1', a_2', \ldots, a_n'$ of the input sequence such that $a_1' \leq a_2' \leq \cdots \leq a_n'$

b.

- Internal Sort
  - The data to be sorted is all stored in the computer's main memory.
- External Sort
  - Some of the data to be sorted might be stored in some external, slower, device.
- In Place Sort
  - The amount of extra space required to sort the data is constant with the input size.
- A Stable sort preserves relative order of object with equal keys in the sorted output as they appear in the input unsorted array.

c. Quick sort Analysis

$T(N) = T(i) + T(N - i - 1) + cN$

The time to sort the file is equal to
the time to sort the left partition with i elements, plus
the time to sort the right partition with N-i-1 elements, plus
the time to build the partitions

Worst case analysis

The pivot is the smallest element

$T(N) = T(N-1) + cN, N > 1$

Telescoping:

$T(N-1) = T(N-2) + c(N-1)$
$T(N-2) = T(N-3) + c(N-2)$
$T(N-3) = T(N-4) + c(N-3)$
$T(2) = T(1) + c.2$

Add all equations:

T(N) + T(N-1) + T(N-2) + … + T(2) =
= T(N-1) + T(N-2) + … + T(2) + T(1) + c(N) + c(N-1) + c(N-2) + … + c.2
T(N) = T(1) + c(2 + 3 + … + N)
T(N) = 1 + c(N(N+1)/2 -1)
Therefore T(N) = $O(N^2)$

Best-case analysis:
The pivot is in the middle
T(N) = 2T(N/2) + cN
Divide by N:
T(N) / N = T(N/2) / (N/2) + c
Telescoping:
T(N/2) / (N/2) = T(N/4) / (N/4) + c
T(N/4) / (N/4) = T(N/8) / (N/8) + c
……
T(2) / 2 = T(1) / (1) + c
Add all equations:
T(N) / N + T(N/2) / (N/2) + T(N/4) / (N/4) + …. + T(2) / 2 =
= (N/2) / (N/2) + T(N/4) / (N/4) + … + T(1) / (1) + c.logN
After crossing the equal terms:
T(N)/N = T(1) + cLogN = 1 + cLogN
T(N) = N + NcLogN
Therefore T(N) = O(NlogN)

d.

Name	Average Case	Worst Case	Memory	Stable	Method
Bubble Sort	$\mathcal{O}\left(n^2\right)$	$\mathcal{O}\left(n^2\right)$	$\mathcal{O}\left(1\right)$	Yes	Exchanging
Selection Sort	$\mathcal{O}\left(n^2\right)$	$\mathcal{O}\left(n^2\right)$	$\mathcal{O}\left(1\right)$	No	Selection
Insertion Sort	$\mathcal{O}\left(n^2\right)$	$\mathcal{O}\left(n^2\right)$	$\mathcal{O}\left(1\right)$	Yes	Insertion
Shell Sort	-	$\mathcal{O}\left(n \log^2 n\right)$	$\mathcal{O}\left(1\right)$	No	Insertion
Merge Sort	$\mathcal{O}\left(n \log n\right)$	$\mathcal{O}\left(n \log n\right)$	$\mathcal{O}\left(n\right)$	Yes	Merging
Heap Sort	$\mathcal{O}\left(n \log n\right)$	$\mathcal{O}\left(n \log n\right)$	$\mathcal{O}\left(1\right)$	No	Selection

COVENANTUNIVERSITY

CANAANLAND, KM 10, IDIROKO ROAD

P.M.B 1023, OTA, OGUN STATE, NIGERIA.

TITLE OF EXAMINATION: B.Sc. EXAMINATION

COLLEGE: College of Science and Technology

DEPARTMENT: Computer and Information Sciences

SESSION: 2015/2016 **SEMESTER:** ALPHA

COURSE CODE: CSC415 **CREDIT UNIT:** 3

COURSE TITLE: Artificial Intelligence

INSTRUCTION: Answer any four questions. **TIME:** 2.5 hours

1a.Explain your understanding of Artificial Intelligence as: i) a model of human intelligence and ii) model of rational behaviour **[6 marks]**

1b. Discuss the fundamental characteristics of AI techniques **[4.5 marks]**

1c. Differentiate between the concept of Good Old Fashioned Artificial Intelligence (GOFAI) and Situated and Embodied Intelligence (SEAI) **[4 marks]**

1d. Give 3 examples of AI-Complete (Hard AI) problems **[3 marks]**

2a. Compare the nature of AI and non-AI problems [**4 Marks**]

2b. Identify 3 different problems within the Covenant University environment that AI can be used to solve. Mention the specific AI techniques that will be essential to tackle the identified problems **[6 marks]**

2c. Analyse the following problems with respect to the 7 problems characteristics

i) Water Jug ii) 8-puzzle **[3 marks]**

2d. Using relevant examples, mention some of the task domains of A.I **[4.5 marks]**

3a. Describe the Simple Hill Climbing Search. Identify its three disadvantages **[5.5 marks].**

3b. Using appropriate examples, differentiate between informed search and un-informed search techniques **[4 marks]**

3c. Compare the Depth-First, Breadth-First algorithms **[3 marks].**

3d. A Robot Tractor has the task to plough a number of farms in a specific farm settlement. The objective is to serve as many farmers in the neighbourhood as possible with its limited fuel and energy level. Describe how a specific heuristic technique that you know can be used to control this Robot Tractor. **[5 marks]**

4a. What are the properties of good knowledge representation? **[4 marks]**

4b. Consider the task of developing a Cognitive Food Selection Assistant (CFSA) that advises students on choice of meals per time.

i) Describe the forms of knowledge that the CFSA must contain **[3 marks]**

ii) Suggest the types of reasoning it should do using relevant examples **[3 marks]**

4c. Using Predicate Logic, show 3 possible rules that the CFSA can use as basis for reasoning **[4.5 marks].**

4d. Highlight three different methods of knowledge representation in A.I. **[3 marks]**

5a. Show a Performance, Environment, Actuators, Sensors (PEAS) description of Software Agent program that can be used to answer frequently asked questions (FAQs) on admission into Covenant University **[5.5 marks].**

5b. Differentiate between a Deterministic Task environment and a Stochastic Task Environment **[4 marks]**

5c. Discuss the different types of Agent programs **[5 marks].**

5d. Differentiate between a database and a knowledge base **[3 marks]**

6a) Consider the expert task of Malaria diagnosis. Show the Design and Description of an Expert System that can adequately replicate this functionality.

i) Show the architecture of the Expert System and the description of its components **[5 marks]**.

ii) Also show sample If-Then-rules that the expert system can use for its reasoning **[2.5 marks]**

6b. Why is learning crucial for Intelligent Systems **[2 marks]**

6c. Describe 5 types of machine learning **[5 marks]**

6d. Discuss briefly 3 instances of biologically inspired AI Systems **[3 marks]**

Marking Scheme – CSC 415

1a.

A.I as a model of human intelligence is premised on the following definitions: (any two required)

i. The exciting new effort to make computers think i.e. machines with minds in the full and literal sense
ii. The automation of activities that we associate with human thinking activities such as decision-making, problem solving, learning etc.
iii. The art of creating machines that performs functions that require intelligence when performed by people
iv. The study of how to make computers do things which at the moment people do better

A.I as a model of rationality: (any two required)

i. The study of mental faculties through the use of computational models
ii. The study of computations that make it possible to perceive reason and act.
iii. A field of study that seeks to explain and emulate intelligent behaviours in terms of computational processes
iv. The branch of Computer Science that is concerned with the automation of intelligent behaviour.

[6 marks]

1b.

Fundamentally, AI Techniques embrace the following concepts

(i) Search – provides a way of solving important problems for which no more direct approach is available as well as a framework into which any direct techniques that are available can be embedded
(ii) Use of Knowledge – Provides a way of solving complex problems by exploiting the structures of the objects that are involved.
(iii) Abstraction – Provides a way of separating important features and variations from the many unimportant ones that would otherwise overwhelm any process.

[4.5 marks]

1c. Differentiate between the concept of Good Old Fashioned Artificial Intelligence (GOFAI) and Situated and Embodied Intelligence (SEAI)

S/no	GOFAI	SEAI
1.	It is based on the assumptions of the Physical Symbol System (PSS)	Not based on PSS

2.	They typically are logic-based reasoning systems	Based on the concept of systems that can sense and act intelligently
3.	Knowledge is represented using symbols	Knowledge is encoded with numbers (binary, decimal and other means)
4.	Reasoning is done using symbolic knowledge	Uses evolutionary approaches
5.	Artificial Intelligence Systems	Artificial life systems with characteristics like synthetic, self-regulating, adaptive, self-organizing, complex
6.	Dominant concept is logical reasoning	Use other approaches to intelligence such as biologically inspired computing such as ANN, Genetic Algorithm, Artificial Immune Systems, Swarm Intelligence etc.

Any 2 can attract full marks - [4 marks]

1d) AI Complete are the set of most difficult AI problems that will require computers to possess a higher level of intelligence – one similar to human level- to be able to solve them. They are also called AI-Hard.

Examples of AI-Complete problems include:
Computer Vision, Natural Language Understanding, Machine Translation, Word Sense Disambiguation, Dealing with unexpected circumstances when solving real life problems [3 marks].

2a.

A.I Problems	Non-A.I Problems
They are poorly Circumscribable	They are perfectly circumscribable
Solution is either rated as adequate or inadequate;	Have exact solution
Solution is not testably correct	There is absolute correctness

Has poor modular approximation	Has good modular approximation

[4 marks]

2b. The examples given by students will be assessed based on the quality of individual presentations. It is expected that student would identify the need for deployment of intelligent systems/agent in several aspect of University's activities. Examples include *intelligent tutoring system, question-answering system, expert system for medical diagnosis, campus route advisory system, cognitive assistant, intelligence surveillance system* etc.

Each student is also expected to mention how identified system can be realised/implemented.

[6 marks]

2c. Analyse the following problems with respect to the 7 problems characteristics

S/no		Water Jug	8-Puzzle
1.	Is problem decomposable or not?	No	No
2.	Can solution steps be ignored or undone?	Yes	Yes
3.	Is the universe predictable?	Yes	Yes
4.	Is a good solution absolute or relative?	absolute	relative
5.	Is the solution a state or a path?	It is State	It is State
6.	What is the role of knowledge?	Significant	Significant
7.	Does the task require human interaction?	Yes	Yes

[3 marks]

2d)

Mundane Tasks

- Perception (vision, speech)

- Natural Language processing (understanding, generation, translation)

- Commonsense reasoning

- Robot control

Formal tasks

- Games (Checkers, Chess, Ayo etc.)

- Mathematics (Geometry, Logic, Calculus, Proving properties of Program)

Expert Tasks:

- Engineering (Design, fault finding, manufacturing planning)

- Scientific analysis

- Medical analysis

- Financial analysis

[4.5 marks]

3a)

Simple Hill Climbing Algorithm

Evaluate the initial state

Loop until solution is found or there are no new operators left to be applied

- select and apply a new operator
- evaluate the new state

3b)

Uninformed search: This is a search strategy in which there is no information about the number of steps or the path from the current state to the goal – all they can do is distinguishing a goal state from a non-goal state. It is sometimes called **blind search**. Examples include; Breadth-first search, Uniform path cost search, Depth-first search, Depth-limited search, Iterative deepening search, and Bidirectional search **[2 marks].**

Informed search: This is a search strategy in which we see how information about the state space can prevent algorithm from blundering about in the dark. It uses problem specific knowledge to find solution more efficiently. It also shows how optimization problems can be solved. Examples include: best-first search, Greedy search, A* search, Heuristic search, Iterative improvement search (such as hill-climbing and simulated annealing) **[2 marks].**

3c)

Comparing Depth-first and Breath-First [3 marks]

S/no		Depth-first	Bread-first
1.	Tree Traversal	Selects a path an explore it, if unsuccessful then backtracks	Traverse the search tree level by level
2.	Time	b^m	b^d
3.	Space	b*m (requires less memory)	b^d (may require more memory)
4.	Optimal?	No (any possible solution can be found first and the search will stop)	Yes (best solution is found first)
5.	Trapped/Dead end	Yes	No
	Where b = branching factor, d= solution depth, m = maximum depth		

3d)

An ideal heuristic to use to solve this problem will be the *branch and bound heuristic* technique.

Application:

Problem definition

Let the set of farms in the neighbourhood F = {f_1, f_2 ...., f_k}

Let C(F) be a function that returns the number of farms that is served in the farm neighbourhood

Let the energy level of the Robot based on the amount of fuel be E.

We need to utilise E in a way that of C(F) → M, where M is the maximum of value of C(F)

i.e. M is the largest number of farmers that can be served by the energy level E of the Robot per time.

Search problem: Therefore, the search problem is to find the longest path in the graph that will ensure utilise the energy of the Robot Tractor.

Branch and bound Technique: Begin by estimating the size of individual farms S, and E required. Devise a path to serve as many farms as possible giving up a path whose estimated work done (expended energy) cum number of farms served is shorter than the longest path found so far, compared to the amount of work done.

Explanation: The branch and bound heuristic could be used to explore the different possible paths to administer the energy of the Robot in order to serve the interest of farmers in the neighbourhood. When it is obvious that a particular chosen path has taken up more energy for fewer number of farms compared to a previously explored path, that path should be discontinued. By so doing, the search process can be accelerated to quickly find the optimal path that will yield the maximum throughput in theirs of serving as many farms as possible.

{hint: student may not be very formal in their presentation, but award full marks if explanation is correct}

[5 marks]

4a) Properties of good knowledge representation

- *Representational Adequacy*: It is the ability to represent all the kinds of knowledge that are needed in that domain **[1 mark]**.
- *Inferential Adequacy*: It is the ability to manipulate the representational structures in such a way as to derive new structures corresponding to the new knowledge inferred from old **[1 mark]**.
- *Inferential Efficiency*: It is the ability to incorporate into the knowledge structures additional information that can be used to focus the attention of the inference mechanism in the most promising directions **[1 mark]**.

- *Acquisitional Efficiency* - the ability to acquire new information easily. It should be possible to make direct insertion into the database and the addition of new knowledge **[1 mark]**.

4b)

Forms of knowledge that the CFSA must contain:

- Data on different types of food and the time of the day when they are most appropriate.

- Data on different ethnic cultures and their food habits

- Different types of eating habits and corresponding food options – e.g. vegetarian, regular eating etc.

- Different types of food and their classification e.g. pasta, local food, cereal, protein etc.

- Data on food nutrients, resident vitamins, and calories

- Data on food and possible alleges etc.

Any two attracts **[2 marks]**

ii) Suggest the type of reasoning it should do using relevant examples **[2 marks]**

Deductive reasoning: that is based on some know facts, the CFSA should recommend appropriate food. A situation where given a case and a rule, the result is inferred.

- If breakfast time (7 – 10 a.m.) THEN food options should be any of (bread, tea and egg) or (yam, egg and tea) or (maize cereal and milk)

Inductive reasoning: if some historical data on eating pattern of the user is available THEN an appropriate food should be recommended for the user. A situation where the rule is inferred given the case and the result.

- *If breakfast food 2 days ago is X and breakfast food yesterday is Y, THEN most appropriate breakfast for today is Z*

Adductive reasoning: A situation where, the case is inferred, given the rule and the result.

- *If the food taken 2 days ago is X and food taken yesterday is Y, THEN it is breakfast food*

Mentioning any 2 attracts full marks

4c. Possible rules for the CFSA using First-order logic **[4.5 marks].**
Answer will be accessed based on individual attempts. Correct attempts will emulate the following:
Rules:

1. If time is morning then food options are Yam and Egg or Bread and Tea
2. If person is vegetarian then food options is without meat

3. If person is African then food options at lunch is local food

FOL:

i) $\forall x, y, z$: time(x) $\wedge$ food_options (y) =>
(recommended_food(z, yam_egg) V recommended_food(z, yam_egg))

ii) $\forall x, y, z$: person(x, Vegetarian) $\wedge$ food_option (y) => $\neg$ recommended_food (z, meat)

iii) $\forall x, y, z$: person(x, African) $\wedge$ food_option (y) => recommended_food (z, local_food)

4d) Methods of knowledge representation in A.I.

First-order logic, Production systems (Prolog, Jess, CLIPS), Frames, Semantic Networks, Ontology [Any four attracts full marks] **[3 marks]**

5a) Performance, Environment, Actuators, Sensors (PEAS) description of Software Agent program that can be used to answer frequently asked questions (FAQs) on admission into Covenant University (CU) **[5.5 marks].**

- **Performance measures:** that will be used to assess whether the agent has fulfilled its goal – provide correct and relevant answers to specific questions on admission into Covenant University.
- **Environment**: description of the environment that the agent will operate – potential *student/parent/user/ administrator, databases, knowledgebase of information on CU*
- **Actuators**: actions or events that will activate the agent – visual displays, touch screen, set of frequently asked questions (FAQs), user query.
- **Sensor**: what the agent will use to accept inputs from the environment - *keyboard entry of topics of interest* **[5.5 marks]**

5b)

Deterministic - If the next state of the environment is completely determined by the current state and the action executed by the agent, then we say the environment is deterministic **[2 marks]**

Stochastic – here the next state of the environment is not completely determined by the current state and the action executed by the agent. **[2 marks]**

5c)

Simple Reflex Agent: This is the simplest kind of agent where agents select actions on the basis of the *current* percept, ignoring the rest of the percept history **[1 marks].**

Model-based Reflex Agent: This type of agent maintains some sort of internal state that depends on the percept history and thereby reflects at least some of the unobserved aspects of the current state **[1 marks].**

Goal-based Agent: This type of agent makes use of some sort of **goal** information that describes situations that are desirable as well as a current state description, to arrive at its conclusion **[1 marks].**

Utility-based Agent: This type of agent not only makes use of use of goal information for its conclusion but also considers the alternatives that guarantee high-quality behaviour in its environment **[1 marks].**
Learning Agent: This type of agent is able to learn from feedback obtained from the environment in the course of solving a problem **[1 marks].**

5d)

A **database** allows the storage and retrieval of data in a way that is efficient. However, it can only guarantee retrieval accuracy i.e. it can retrieve verbatim what has been stored in it, but cannot support making inference or deductions based on what is stored.
A **knowledgebase** allows data to be organized in way that direct data retrieval, inferences and deductions can be made based on what is stored. **[3 marks]**

6a)

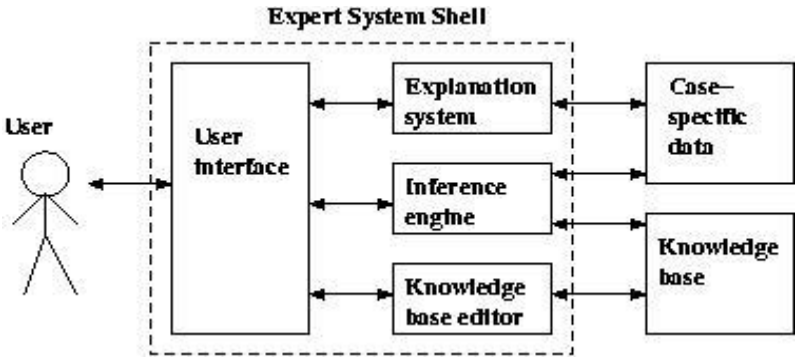


Figure 1: A typical Expert System Architecture

The student is expected to describe the different components of the Expert System Architecture in a way that is specific to malaria diagnoses. Attempts will be accessed on merit of presentation.

Figure 1 shows the most important modules that make up a rule-based expert system. The user interacts with the system through a *user interface* which may use menus, natural language or any other style of interaction). Then an *inference engine* is used to reason with both the *expert knowledge* (extracted from our friendly

expert) and data specific to the particular problem being solved. The expert knowledge will typically be in the form of a set of IF-THEN rules. The *case specific data* includes both data provided by the user and partial conclusions (along with certainty measures) based on this data. In a simple forward chaining rule-based system the case specific data will be the elements in *working memory*.

[2.5 marks
]

6b) Learning is essential to Machine Intelligence because machines can only exhibit intelligence after knowledge as been acquired through learning which then forms the basis for intelligence **[2 marks]**

6c. Describe 5 types of machine learning

- **Rote Learning**: The system is given confirmation of correct decisions. When it is produces incorrect decision it is "spoon fed" with the correct rule or relationship that it should have used.
- **Learning from Advice**: Rather than being given a specific rule that should apply in a given circumstance, the system is given a piece of general advice, such as "gas is more likely to escape from a valve than from a pipe". The system must sort out for itself how to move from this high level advice to an immediately usable rule.
- **Learning by Induction**: The system is presented with sets of example data and is told the correct conclusion that is should draw from each. The system continually refines its rules and relations to correctly handle each new example.
- **Learning by Analogy**: The system is told the correct response to a similar, but not identical task. The system must adapt the previous response to generate a new rule applicable to the new circumstances.
- **Explanation-Based Learning (EBL)**: The system analyzes a set of examples solutions and their outcomes to determine why each one was successful or otherwise. Explanations are generated, which are used to guide future problem solving. An example of an EBL system is PRODIGY (a general purpose problem-solver).
- **Case-Based Reasoning (CBR)**: Any case about which the system has reasoned is filed away, together with the outcome, whether it is successful or otherwise. Whenever a new case is encountered, the system adapts its stored behaviour to fit the new circumstances.
- **Explorative or Unsupervised Learning**: This is also called discovery learning, rather than having an explicit goal, an explorative system continuously searches for patterns and relationships in the input data, perhaps marking some patterns as interesting and warranting further investigation. Examples of application of unsupervised learning can be found :
    - data mining : where patterns are sought among large or complex data sets;
    - Identifying clusters, possibly for compressing the data;
    - Feature recognition

(Any five will be sufficient) – **[5 marks]**.

6d) Examples of Biologically inspired AI Systems **[3 marks]**

- **Genetic Algorithms**: Based on the functioning of the biological process of evolution. It artificially emulates the concepts of variation, selection based on the fitness function and inheritance.
- **Artificial Neural Networks**: emulates the human biological brain network to solve problems. Use adaptive learning to solve complex classification and regression problems
- **Swarm Intelligence**: **It** is the collective behaviour of decentralized, self-organized systems, natural or artificial. It is an attempt to emulate the collective intelligent behaviour of some known biological ecosystems. Natural examples of SI include *ant colonies*, *bird flocking*, *animal herding*, *bacterial growth*, and *fish schooling*.
- **Artificial Immune Systems**: These are class of computationally intelligent systems inspired by the principles and processes of the vertebrate immune system. The algorithms typically exploit the immune system's characteristics of learning and memory to solve a problem.

[Any 3 with light explanation attracts full marks]

COVENANTUNIVERSITY

CANAANLAND, KM 10, IDIROKO ROAD

P.M.B 1023, OTA, OGUN STATE, NIGERIA.

TITLE OF EXAMINATION: B.Sc EXAMINATION

COLLEGE: College of Science and Technology

SCHOOL: Natural and Applied Sciences

DEPARTMENT: Computer and Information Sciences

SESSION: 2014/2015 **SEMESTER:** ALPHA

COURSE CODE: CSC415 **CREDIT UNIT:** 2

COURSE TITLE: Artificial Intelligence

INSTRUCTION: Answer any four questions. **TIME:** 2

1a. Explain your understanding of Artificial Intelligence as: i) a model of human intelligence and ii) model of rational behaviour **[5 marks]**

1b. Differentiate between Artificial Intelligent systems and Artificial Life systems **[5 marks]**

1c. Discuss the relevance of heuristic search techniques in solving A.I. problems **[2.5 marks]**

1d. Differentiate between AI problems and non-AI problems **[5 marks]**

2a. Assume you have the task to design a software agent that will efficiently distribute available bandwidth to different users with varying bandwidth requirements on a Corporate Computer Network, so that as many persons as possible are served. Discuss a suitable heuristic that the software agent can use in order to achieve optimal bandwidth distribution for users on network **[6.5 marks]**

2b. Discuss the any four of the characteristics of computational problems **[4 marks]**

2c. Highlight the main A.I tasks domains, citing relevant examples **[5 marks]**

2d. Give 2 examples of AI-Complete (Hard AI) problems **[2 marks]**

3a. Find a good state space representation for the Water Jug Problem **[5.5 marks]**

3b. Compare the Breath-first and the Depth-First search Algorithm **[4 marks]**

3c. Using relevant examples compare informed search and un-informed search techniques **[4 marks]**

3d. Give an outline of the Iterative Deepening Search Algorithm **[4 marks]**

4a. Describe briefly four different types of Semantic Networks **[4 marks]**

4b. Discuss four different types of Agent programs **[4 marks].**

4c. What are the properties of good knowledge representation? **[4 marks]**

4d. Consider the task of developing an Intelligent Tutoring System (ITS) for the AI course. Describe the components of the IT, and show the Performance, Environment, actuators, Sensors (PEAS) description of such an intelligent Tutoring System **[5.5 marks].**

5a. Show the knowledge representation of the following facts using First-order logic

i) Not all student take both History and Biology
ii) Only one student failed History
iii) No person likes Dull Pets **[6 marks]**

5b. Why is learning crucial for Intelligent Systems **[2.5 marks]**

5c. Using relevant examples describe 5 types of machine learning techniques **[5 marks]**.

5d. Differentiate between symbolic learning and numerical learning **[2 marks]**

6. Consider the expert task of recommending the most appropriate books on specific subjects for students to read. Assume you have been assigned the task of designing an Expert System that can perform this task.

a. Discuss the architecture of the Expert System and the description of its components **[5 marks]**.

b. Using relevant examples, describe the inference mechanism that the expert system would use **[2.5 marks]**

c. Discuss the implementation tools and artefacts you would use to realize the Expert System. **[3 marks]**

d. Highlight the possible limitations of your system based on your chosen system design choices. **[4 marks]**

CSC415 Marking Scheme – Artificial Intelligence

1a.

The notion of A.I as a model of human intelligence is based on the following definitions: (any two required)

v. The exciting new effort to make computers think i.e. machines with minds in the full and literal sense
vi. The automation of activities that we associate with human thinking activities such as decision-making, problem solving, learning etc.
vii. The art of creating machines that performs functions that require intelligence when performed by people
viii. The study of how to make computers do things which at the moment people do better

[2.5 marks]

A.I as a model of rationality: (any two required)

v. The study of mental faculties through the use of computational models
vi. The study of computations that make it possible to perceive reason and act.
vii. A field of study that seeks to explain and emulate intelligent behaviours in terms of computational processes
viii. The branch of computer science that is concerned with the automation of intelligent behaviour.

[2.5 marks]

1b.

Artificial Intelligent (A.I.) Systems – the basis for intelligence is from reasoning on knowledge that have been stored in them or just acquired in the course of usage. They are typically reasoning systems that require a good knowledge base to make inferences. **[2.5 marks]**

Artificial Life Systems (ALife) – are called situated and embodied artificial intelligent (SEAI) systems because they possess additional characteristics that make them to learn and adapt to their environment dynamically and independently. The characteristics of ALife system include – synthesis, self-organizing, self-regulating, adaptive, and complex **[2.5 marks]**

1c.

The complexity of most A.I problems is NP, which require a brute-force search.

- Heuristic search techniques take advantage of knowledge to produce good but less than optimal solution.
- A heuristic is a technique that improves the efficiency of a search process, possibly by sacrificing claims of completeness. It is a control structure that is not guaranteed to find the best answer but will always find a good answer.
- Heuristics are rules of the thumbs that can guide for correctness unlike algorithms.
- Heuristics help to find good though non-optimal solutions to NP problems.
- Heuristics methods such as Nearest neighbour heuristic, error bounds, branch and bound have been used to solve many NP problems.

(Any 2 points mentioned attracts full marks) – **2.5 marks**

1d.

A.I Problems	**Non-A.I Problems**
They are poorly Circumscribable	They are perfectly circumscribable
Solution is either rated as adequate or inadequate;	Have exact solution
Solution is not testably correct	There is absolute correctness
Has poor modular approximation	Has good modular approximation

[5 marks]

2a.

An ideal heuristic to use to solve this problem will be the *branch and bound heuristic* technique.

Application:

Problem definition

Let the set of network nodes N = {n_1, n_2 ...., n_k}

We need to distribute bandwidth of size P among the members of Set N, such that C ϵ N is the largest subset of N, i.e. the largest number of users that can be allocated bandwidth

Search problem: Hence, the search problem is to find the longest path in the network that will ensure distribution of bandwidth of size P.

Branch and bound Technique: Begin by generating complete paths to distribute P, keeping track of the longest path found so far and the amount of P that has been distributed. Give up exploring any path as soon as its partial length becomes shorter than the longest path found so far, compared to the amount of P that has been distributed.

Explanation: The branch and bound heuristic could be used to explore the different possible paths to allocate the units of memory P to different nodes in the network based on their bandwidth requirements. When it is obvious that a particular chosen path has taken up more bandwidth to fewer number of network nodes compared to a previously explored path, that path should be discontinued. By so doing, the search process can be accelerated to quickly find the optimal path that will yield the maximum possible ways of distributing P to network nodes.

{hint: student may not be very formal in their presentation, but award full marks if explanation is correct}

[6.5 marks]

2b. Characteristics of computational problems

- *Decomposable problems*: problems that can be decomposed into smaller or easier components.
- *Ignorable problems*: solution steps can be ignored when considered not necessary (e.g. theorem proving).
- *Recoverable problems*: in which solutions steps can be undone.
- *Irrecoverable problems*: in which solutions steps cannot be undone.
- *Certain-outcome problems*: lead to definite outcome.
- *Uncertain-outcome problems*: produces a probability to lead to a solution (the hardest problems to solve are those that are irrecoverable, uncertain- outcome) e.g. advising a lawyer who is defending a client who is standing trial for murder.
- *Problems that require absolutely good solution* and those that require relatively good solution e.g. travelling salesman algorithm (Any-path/Best path) problem.
- *Problem that require a solution as state or path*.

[4 marks] listing any 4 attracts full marks

2c. A.I task domains

Mundane Tasks

- perception (vision, speech)

- Natural Language processing (understanding, generation, translation)

- Commonsense reasoning, Robot control

Formal tasks

- Games (Checkers, Chess, Ayo etc.)

- Mathematics (Geometry, Logic, Calculus, Proving properties of Program)

Expert Tasks

- Engineering (Design, fault finding, manufacturing planning)

- Scientific analysis, Medical analysis, Financial analysis

5 Marks - minimum of 2 examples in each category will attract full marks

2d**.**

AI Complete are the class of most difficult AI problems that cannot be solved by simple algorithmic approaches. Examples include **Computer vision**, **natural language understanding**, **machine translation**, **dealing with unexpected circumstances while solving real problems**. **[2 marks]**

3a. Find a good state space representation for the Water Jug Problem **[5.5 marks]**

State Spaces for Water Jug Problem

• A state: (x, y)

x = 0, 1, 2, 3, or 4 y = 0, 1, 2, or 3.

• Start state: (0, 0).

• Goal state: (2, n) for any n, n = 0, 1, 2, 3.

[1.5 marks]

Rules for transition

No.	Left	Right	Description
1	(x, y) & x < 4	→ (4, y)	Fill the 4–litre jug
2	(x, y) & y < 3	→ (x, 3)	Fill the 3–litre jug
3	(x, y) & x > 0	→ (0, y)	Empty the 4–litre jug
4	(x, y) & y > 0	→ (x, 0)	Empty the 3–litre jug
5	(x, y) & x + y >= 4 & y > 0	→ (4, y - (4 - x))	Pour water from 3–litre jug into 4–litre jug until the 4–litre jug is full
6	(x, y) & x + y >= 3 & x > 0	→ (x - (3 - y), 3)	Pour water from 4–litre jug into 3–litre jug until the 3–litre jug is full

No.	Left	Right	Description
7	(x, y) & x + y <= 4 & y > 0	→ ((x + y), 0)	Pour all the water from 3–litre jug into 4–litre jug
8	(x, y) & x + y <= 3 & x > 0	→ (0, (x + y))	Pour all the water from 4–litre jug into 3–litre jug

[1.5 marks]

Applying Transition Rules

1. current state = (0, 0)

2. Loop until reaching the goal state (2, 0)

– Apply a rule whose left side matches the current state

– Set the new current state to be the resulting state

(0 0) 2nd rule

(0 3) 7th rule

(3 0) 2nd rule

(3 3) 7th rule

(4 2) 3rd rule

(0 2) 7th rule

(2 0) – **Goal** **[2.5 marks]**

3b.

Breadth First

- The algorithm explore the tree one level at a time , therefore will not get trapped after exploring a wrong path
- If there is a solution the breadth first will find it, though it may take time. Also, if there are multiple solutions, the minimal solution will be found. This is because the longer paths are never examined until all the shorter ones have been examined. **[2 marks]**

Depth First

- Pursues a single branch of the tree until it yields a solution or until a decision to terminate the path is made (i.e. when it reaches a dead end, when the length of the path exceeds the Futility Limit). Thereafter backtracking occurs. It backtracks to the most recently created state from which alternative moves are available.
- Requires less memory since only the nodes on the current path are stored, this contrast with breadth-first search, where all of the tree that has so far been generated must be stored.
- By chance (if care is taken in ordering the alternative successor states), may find solution without much searching.
- In breadth first all nodes at level n must be examined before any node on level n+1 can be examined. This is particularly significant if many acceptable solutions exist. Depth-first search can stop when one of them is found.
- The wrong path may be followed, and it can get trapped if there are loops on that path.
- May find a solution on a loop path of a tree not necessarily the nominal path.

[2 marks] – *mentioning any 2 or 3 significant characteristics attracts full marks*

3c.

Uninformed search: This is a search strategy in which there is no information about the number of steps or the path from the current state to the goal – all they can do is distinguishing a goal state from a non-goal state. It is sometimes called **blind search**. Examples include; Breadth-first search, Uniform path cost search, Depth-first search, Depth-limited search, Iterative deepening search, and Bidirectional search. **[2 marks]**

Informed search: This is a search strategy in which we see how information about the state space can prevent algorithm from blundering about in the dark. It uses problem specific knowledge to find solution

more efficiently. It also shows how optimization problems can be solved. Examples include: best-first search, Greedy search, A^* search, Heuristic search, Iterative improvement search (such as hill-climbing and simulated annealing). **[2 marks]**

3d.

Procedure Iterative-deepening
Begin
1. Set current depth cutoff =1;
2. Put the initial node into a stack, pointed to by stack-top;
3. **While** the stack is not empty and the depth is within the given depth cut-off do

Begin
Pop stack to get the stack-top element;
if stack-top element = goal, return it and stop
else push the children of the stack-top in any order into the stack;

End While;
4. Increment the depth cut-off by 1 and repeat through step 2;

End. **[4 marks]**

4a. Types of Semantic Networks **[4 marks]**

- *Definitional networks* emphasize the *subtype* or *are-a* relation between a concept type and a newly defined subtype. The resulting network, also called a *generalization* or *subsumption* hierarchy, supports the rule of *inheritance* for copying properties defined for a supertype to all of its subtypes. Since definitions are true by definition, the information in these networks is often assumed to be necessarily true. **[1 mark]**

- *Assertional networks* are designed to assert propositions. Unlike definitional networks, the information in an assertional network is assumed to be contingently true, unless it is explicitly marked with a modal operator. Some assertional netwoks have been proposed as models of the *conceptual structures* underlying natural language semantics. **[1 mark]**
- *Implicational networks* use implication as the primary relation for connecting nodes. They may be used to represent patterns of beliefs, causality, or inferences.
- *Executable networks* include some mechanism, such as marker passing or attached procedures, which can perform inferences, pass messages, or search for patterns and associations.
- *Learning networks* build or extend their representations by acquiring knowledge from examples. The new knowledge may change the old network by adding and deleting nodes and arcs or by modifying numerical values, called *weights*, associated with the nodes and arcs.
- *Hybrid networks* combine two or more of the previous techniques, either in a single network or in separate, but closely interacting networks.

[4 marks]

4b. Discuss the four different types of Agent programs **[4 marks].**

Simple Reflex Agent: This is the simplest kind of agent where agents select actions on the basis of the *current* percept, ignoring the rest of the percept history **[1 marks].**

Model-based Reflex Agent: This type of agent maintains some sort of internal state that depends on the percept history and thereby reflects at least some of the unobserved aspects of the current state **[1 marks].**

Goal-based Agent: This type of agent makes use of some sort of **goal** information that describes situations that are desirable as well as a current state description, to arrive at its conclusion **[1 marks].**

*Utility-based Agent***:** This type of agent not only makes use of use of goal information for its conclusion but also considers the alternatives that guarantee high-quality behaviour in its environment **[1 marks].**

*Learning Agent***:** This type of agent is able to learn from feedback obtained from the environment in the course of solving a problem **[1 marks].**

4c. The properties of good knowledge representation are the following:

- *Representational Adequacy***:** It is the ability to represent all the kinds of knowledge that are needed in that domain **[1 mark]**.
- *Inferential Adequacy***:** It is the ability to manipulate the representational structures in such a way as to derive new structures corresponding to the new knowledge inferred from old **[1 mark]**.
- *Inferential Efficiency***:** It is the ability to incorporate into the knowledge structures additional information that can be used to focus the attention of the inference mechanism in the most promising directions **[1 mark]**.
- *Acquisitional Efficiency* - the ability to acquire new information easily. It should be possible to make direct insertion into the database and the addition of new knowledge **[1 mark]**.

4d. Components and PEAS description of an Intelligent Tutoring System

Attempts will be assessed on individual merit. A student is expected to show a table consisting of the following:

The ITS is expected to include the following:

Tutor module: This is the engine of the ITS that coordinate appropriate delivery of content based on user preferences.

Knowledgebase: the expert domain knowledge content of the ITS will be stored here, with appropriate inference mechanism that determine the nature of instruction to students

GUI module: enable interaction with the user

[3 marks]

- **Performance metrics:** that will be used to assess whether the agent has fulfilled its goal – provide content-based instruction on specific topics in the AI course.

- **Environment**: description of the environment that the agent will operate – *student/user, administrator*

-**Actuators**: actions or events that will activate the agent – visual displays, touch screen, questions, user query.

-**Sensor**: what the agent will use to accept inputs from the environment - *keyboard entry of topics of interest.*

[2.5 marks]

5a.

i) Not all student take both History and Biology

$\forall$ *student(x) =>* ┐ *(take(x, History) Λ take(x, Biology))*

[2 marks]

ii) Only one student failed History

$\forall$ *student(x, onlyone) => student_failed(x, history)*

[2 marks]

iii) No person likes Dull Pets

$\forall$ *pet(x) Λ dull(x) =>* ┐ *likes (x, person)*

[2 marks]

5b.

Learning is essential to Machine Intelligence because machines can only exhibit intelligence after knowledge as been acquired through learning which then forms the basis for intelligence **[2.5 marks]**

5c. Machine Learning techniques.

- **Rote Learning**: The system is given confirmation of correct decisions. When it is produces incorrect decision it is "spoon fed" with the correct rule or relationship that it should have used.
- **Learning from Advice**: Rather than being given a specific rule that should apply in a given circumstance, the system is given a piece of general advice, such as "gas is more likely to escape from a valve than from a pipe". The system must sort out for itself how to move from this high-level advice to an immediately usable rule.
- **Learning by Induction**: The system is presented with sets of example data and is told the correct conclusion that is should draw from each. The system continually refines its rules and relations so as to correctly handle each new example.

- **Learning by Analogy**: The system is told the correct response to a similar, but not identical task. The system must adapt the previous response to generate a new rule applicable to the new circumstances.
- **Explanation-Based Learning (EBL)**: The system analyzes a set of examples solutions and their outcomes to determine why each one was successful or otherwise. Explanations are generated, which are used to guide future problem solving. An example of an EBL system is PRODIGY (a general purpose problem-solver).
- **Case-Based Reasoning (CBR)**: Any case about which the system has reasoned is filed away, together with the outcome, whether it is successful or otherwise. Whenever a new case is encountered, the system adapts its stored behaviour to fit the new circumstances.
- **Explorative or Unsupervised Learning**: This is also called discovery learning, rather than having an explicit goal, an explorative system continuously searches for patterns and relationships in the input data, perhaps marking some patterns as interesting and warranting further investigation. Examples of application of unsupervised learning can be found :
  - data mining : where patterns are sought among large or complex data sets;
  - Identifying clusters, possibly for compressing the data;
  - Feature recognition

[5 marks] – Any 5 attracts full marks.

5d. Differentiate between a database and a knowledgebase **[4 marks**].

Machine Learning can be broadly classified in terms of how the learning artifact (data/model) that the system is expected to learn is represented.

Symbolic learning: describes systems that formulate and modify rules, facts, and relationships, explicitly represented in words or symbols. In other words, they create and modify their own knowledge base. **[2 marks]**

Numerical learning: refers to systems that use numerical models, where certain techniques are used for optimizing the numerical parameters. Examples include neural networks, genetic algorithms and simulated annealing. **[2 marks]**

6. Expert System for book recommendation
Attempts will be assessed on individual merit
6a.The student is expected to describe the different components of the Expert System (Recommender System) Architecture. The system architecture could be on knowledge-based, content-based, case-based, or collaborative filtering.

Basically the expert system architecture is expected to have the following:

User Interface: with which the user will interact with the system. This may use menus, natural language or any other style of interaction).

Inference engine: This is used to reason on the knowledge stored in the knowledgebase. Reasoning will be triggered based on specific algorithms depending on the selected approach to achieve the recommendation.

Knowledgebase: This is the *expert knowledge, which exist either as* stored facts about different books and authors, or rating of different books by different users.

Explanation System: This will provide rational for the result of the system.

[5 marks]

6b.

The approach by students for inference mechanism /reasoning approach would be varied.

i) For those that chose to use a content-based or knowledge-based approach, where a set of rules or fuzzy rule-based are stored in a knowledgebase. Then expert system inference engines such as PROLOG, JESS, CLIPs, Fuzzy inference engines (e.g. MATLAB) expected.

ii) For those that chose a collaborative filtering approach, then the matching of ratings of different books by different users are expected to be matched using some similarity metrics (Pearson-Correlation, Cosine, Jaccard etc.) to determine the recommendation. **[2.5 marks]**

6c.

Perspective of implementation of the system by students would defer in terms of implementation and deployment platforms. Some may favour web-based, while other may target stand alone (enterprise systems).

Web-based: web tools (**Language** - PHP, ASP, JAVA, C#, C++, VB.Net or other server-side scripting languages; **Web design** – HTML, Dream Weaver, Flash etc.; **Web Servers** - WAMP, Apache/tomcat/ etc.; **Database** - MS SQL, MySQL, Knowledge base – PROLOG, JESS, CLIP etc. and the like are expected to be mentioned.

Standalone: All of the above except web-specific choices. **[3 marks]**

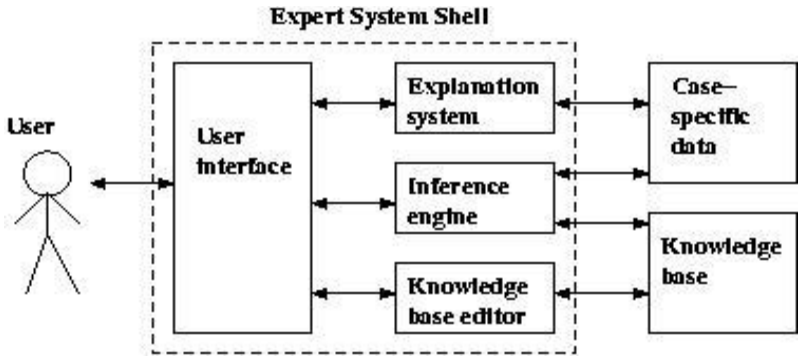
6d. Possible limitations of the system **[4 marks]**

Possible limitations of the Expert system- arguments are expected to be in the following lines of reasoning:

- quality of specified rules will determine the correctness of results (precision). Poorly specified rules will yield poor result.

- nature of rules matching that determines which rules are fired, is it partial matching (approximate) or exact matching

- response time, as number of rules grow. This depends on the capacity of the inference engine, and a major limitation for hardcoded rules stored in a database. **[4 marks]**



COVENANT UNIVERSITY

CANAANLAND, KM 10, IDIROKO ROAD
P.M.B 1023, OTA, OGUN STATE, NIGERIA.

TITLE OF EXAMINATION: B.Sc EXAMINATION
COLLEGE: College of Science and Technology
DEPARTMENT: Department of Computer and Information Sciences
SESSION: 2015/2016 **SEMESTER:** ALPHA
COURSE CODE: CSC 431 **CREDIT UNIT:** 3
COURSE TITLE: Computational Science & Numerical Methods
INSTRUCTION: Answer ANY 4 questions **TIME**: 3 HOURS

---

1. (a) List the different numerical methods for finding the roots of an equation? Comment on each one in terms of its conditions and rate of convergence. (6 marks)
   (b) Given the function f(x) = $x^3 - e^{-0.5x}$, use the bisection method to find the root of the equation. Start with $a = 0$ and $b = 1$, and carry out the first four iterations. (6 marks)
   (c) Hence, write a C / C++ / C# program to find the root of the function in 1a and compute the relative error for each iteration. Your program should output a, b, c, f(a), f(b), f(c), relative error after each iteration and the root of the equation at the end. (5½ marks)

2. (a) Given f(x) = cos(*x*) + 2 sin(*x*) + x^2 with initial values $x_{-1} = 0$ and $x_0 = -0.1$. Use the secant method to find the root of the equation. Given an error tolerance of 0.001, find the absolute error at the end of each iteration. (9 marks)
   Hint: Use the error tolerance as a basis to stop your iterations. Use radian to find trigonometric values on your calculator.
   (b) Write a C / C++ / C# program for 2a. Your program should be generic i.e. the initial values, and error tolerance should be supplied by the user. (4½ marks)
   (c) Determine the root of the function f(x) = $x^3 - e^{-0.5x}$. Using Newton's method. Start at $x_1 = 1$ and carry out the first four iterations. (4 marks)

3. You are working for "DOWN THE TOILET COMPANY" that makes floats for ABC commodes. The floating ball has a specific gravity of 0.6 and has a radius of 5.5cm. You are asked to find the depth to which the ball is submerged when floating in water. The equation that gives the depth to which the ball is submerged under water is given by

$$x^3 - 0.165x^2 + 3.993\times10^{-4} = 0$$

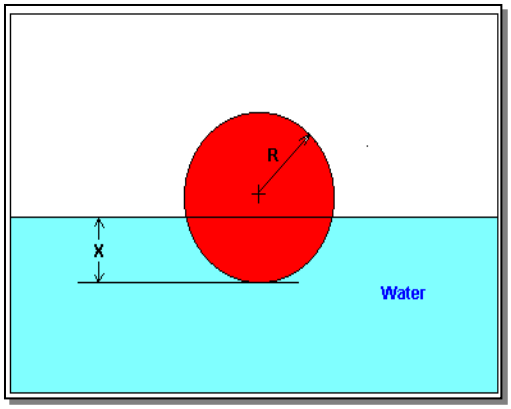


Figure 1 Floating ball problem

(a) Use the false-position method of finding roots of equations to find the depth to which the ball is submerged under water. Conduct three iterations to estimate the root of the above equation. (6 marks)

(b) Find the percentage relative error at the end of each iteration in 3a. (6 marks)

(c) Write a C / C++ / C# program for 3a and 3b. (5½ marks)

4. (a) Give the pseudocodes for Guassian elimination methods. (4 marks)

(b) The upward velocity of a rocket is given at three different times in the table below:

Velocity vs. time data.

Time, t (s)	Velocity, v (m/s)
5	106.8
8	177.2
12	279.2

The velocity data is approximated by a polynomial as $v(t) = a_1 t^2 + a_2 t + a_3$, $5 \le t \le 12$

The coefficients a_1, a_2, and a_3 for the above expression are given by

$$\begin{bmatrix} 25 & 5 & 1 \\ 64 & 8 & 1 \\ 144 & 12 & 1 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} 106.8 \\ 177.2 \\ 279.2 \end{bmatrix}$$

Find the values of a_1, a_2, and a_3 using the Naïve Gauss elimination method. Find the velocity at $t = 6, 7.5, 9, 11$ seconds. (10 marks)

(c) Write a C / C++ / C# program using the Lagrange interpolation to estimate the value of a function at a particular point given n known points. (3½ marks)

5. (a) Using the following table;

0	7
1	13
2	21
4	43

i. Explicitly construct the Lagrange Interpolating polynomial $P_3(x)$.

ii. Interpolate f(3) (6 marks)

(b) Given the following table of values:

x	1	1.5	2.5
$f(x)$	0	0.4055	0.9163

i. Compute the coefficients of the Newton interpolating polynomial $P_2(x)$ using divided differences.

ii. Interpolate f(1.9). ($5\frac{1}{2}$ marks)

(c) Given the following table:

x	1	1.5	2	3	3.5
$f(x)$	0	0.17609	0.30103	0.4772	0.54407

i. Construct the table of divided differences.

ii. Using the divided differences, construct $P_4(x)$ and interpolate f(2.5). (6 marks)

6. (a) A ball of 1200K is allowed to cool down in air at an ambient temperature of 300K. Assuming heat is lost only due to radiation, the differential equation for the temperature of the ball is given by;

$$\frac{d\theta}{dt} = -2.2067x10^{-12}(\theta^4 - 81x10^8) \qquad \theta(0) = 1200K$$

Find the temperature at t = 480 seconds using RK2 Heun's method. Assume a step size of h = 240 seconds. ($5\frac{1}{2}$ marks)

(b) Given that $\frac{dy}{dx} = 1 + y + x^2$ and $y(0) = 0.5$. Using RK4 and a step size of 0.2, find $y(0.4)$. (6 marks)

(c) The concentration of salt in a homemade soap maker is given as a function of time by

$$\frac{dx}{dt} = 37.5 - 3.5x$$

At the initial time, t=0, the salt concentration in the tank is 50 g/L. Using RK2 Euler's method and a step size of h=1.5, what is the salt concentration after 3 minutes? (6 marks)

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Marking Scheme

1a. $1^1/_2$marks each = 6 marks

Bisection Method
Condition: Continous function f(x) in [a,b] satisfying f(a)f(b) < 0
Convergence: Slow but sure. Linear
False position Method
Condition: Continous function f(x) in [a,b] satisfying f(a)f(b) < 0
Convergence: Slow (linear)
Newton's Method
Condition: Existence of non zero f ´(x)
Convergence: Fast (quadratic)
Secant Method
Condition: Existence of non zero f $(x_{n+1}) - f(x_n)$
Convergence: Fast (quadratic)

b. $1^1/_2$marks for each iteration= 6 marks

$x^3 - e^{-0.5x}$

i = 1, a = 0, b = 1, f(0) = $0^3 - e^{-0.5(0)} = -1$, f(1) = $1^3 - e^{-0.5(1)} = 0.39347$,

$$x_{NSI} = \frac{0+1}{2} = 0.5$$

f(0.5) = $0.5^3 - e^{0.5(0.5)} = -0.6538$

i = 2, a = 0.5, b = 1, $x_{NS2} = \frac{0.5+1}{2} = 0.75$, f(0.75) = $0.75^3 - e^{-0.5(0.75)} = -0.26541$

i = 3, a = 0.75, b = 1, $x_{NS3} = \frac{0.75+1}{2} = 0.875$, f(0.875) = $0.875^3 - e^{-0.5(0.875)} = 0.024273$

i = 4, a = 0.75, b = 0.875, $x_{NS4} = \frac{0.75+0.85}{2} = 0.8125$,

$f(0.8125) = 0.8125^3 - e^{-0.5(0.8125)} = -0.12977$

c. //C++ Program to find roots of f(x) using the bisection method

```
#include <iostream>
#include <iomanip>
#include <conio.h>
#include <math.h>
using namespace std;
//define the function for which we want to find the roots
float f (float x)
{
    float fx;
    fx = pow(x,3) - exp(-0.5*x);
    return (fx);
}
int main()
{
      float a,b,c;
      float cprev;
      float relerr, err; //the wanted error tolerance
      int iter; //iteration counter

      cout <<"Enter a = ";
      cin >> a;
      cout <<"Enter b = ";
      cin >> b;
      cout <<"Enter the error tolerance = ";
      cin >> err;
      cout << "Enter the number of iterations = ";
      cin >> iter;
      int count=0;
      cprev=b;
      do
      {
            c = (a + b)/2.0; //find the midpoint

            cout << "a=" << a <<" | b="<< b <<" | c=" << c <<" | " << "
            f(a)=" << f(a) << " |  f(b)=" << f(b) << " |  f(c)=" <<
            f(c) << endl << endl;

            if( f(a) * f(c) < 0 ) //root in the left half
            {
                  b = c;
            }
            else //root in the right half
            {
```

½ mark

1 mark

1 mark

1½ marks

```
                a = c;
            }
            relerr = (fabs(c - cprev)/ fabs(c));
            cprev=c;
            cout<<"Relative error is  " << relerr <<endl << endl;
            count++;
        }


while( count < iter); //condition to stop

        cout << fixed << "The root of the equation is  " <<
        setprecision(4) << c << endl << endl;
        return 0;
}
```

½ marks

1 mark

2.

a) 1½ marks for each iteration= 9 marks

The secant method applied to $f(x) = \cos(x) + 2\sin(x) + x^2$.

n	x_{n-1}	x_n	x_{n+1}	$\lvert f(x_{n+1})\rvert$	$\lvert x_{n+1} - x_n\rvert$
1	0.0	-0.1	-0.5136	0.1522	0.4136
2	-0.1	-0.5136	-0.6100	0.0457	0.0964
3	-0.5136	-0.6100	-0.6514	0.0065	0.0414
4	-0.6100	-0.6514	-0.6582	0.0013	0.0068
5	-0.6514	-0.6582	-0.6598	0.0006	0.0016
6	-0.6582	-0.6598	-0.6595	0.0002	0.0003

Thus, with the last step, both halting conditions are met, and therefore, after six iterations, our approximation to the root is -0.6595 .

b)

//C++ program

```
#include <iostream>
#include <iomanip>
#include <conio.h>
#include <math.h>
using namespace std;

//define the function for which we want to find the roots
float f (float x)
{
    float fx;
    fx = cos(x) + (2*sin(x)) + pow(x,2);
    return (fx);
```

½ mark

1 mark

```
}

int main()
{
    float a,b,c;
    float err, abserr;

    cout <<"Enter a = ";
    cin >> a;
    cout <<"Enter b = ";
    cin >> b;
    cout <<"Enter the error tolerance = ";
    cin >> err;

do
    {

        c = b - (f(b)*(b-a))/(f(b)-f(a));
        abserr=fabs(c-b);
        a=b;
        b=c;
        cout<< "The Absolute Error is " << abserr <<endl << endl;
    }
    while(abserr > err); //condition to stop
      cout << fixed << "The root of the equation is  " <<
      setprecision(4) << c << endl << endl;
      return 0;
}
```

1 mark

1 mark

1 mark

c) 1 mark for each iteration= 4 marks

$$f(x) = x^3 - e^{-0.5x}, f' = 3x^2 + 0.5e^{-0.5x}, x_{i+1} = x_i - \frac{f(x_i)}{f'(x_i)}$$

$$= x_i - \frac{x^3 - e^{-0.5x}}{3x^2 + 0.5e^{-0.5x}}$$

$$i = 1, \quad x_1 = 1, x_2 = 1 - \frac{1^3 - e^{-0.5(1)}}{3(1^2) + 0.5e^{-0.5(1)}} = 0.88088$$

$$i = 2, \quad x_3 = 0.88088 - \frac{0.88088^3 - e^{-0.5(0.88088)}}{3(0.88088^2) + 0.5e^{-0.5(0.88088)}} = 0.86618$$

$$i = 3, \quad x_4 = 0.86618 - \frac{0.86618^3 - e^{-0.5(0.86618)}}{3(0.86618^2) + 0.5e^{-0.5(0.86618)}} = 0.86565$$

$$i = 4, \quad x_5 = 0.86565 - \frac{0.86565^3 - e^{-0.5(0.86565)}}{3(0.86565^2) + 0.5e^{-0.5(0.86565)}} = 0.86565$$

3a & b.

From the physics of the problem, the ball would be submerged between $x = 0$ and $x = 2R$,

where

$$R = \text{radius of the ball,}$$

that is

$$0 \le x \le 2R$$

$$0 \le x \le 2(0.055)$$

$$0 \le x \le 0.11$$

Let us assume

$$x_L = 0,\ x_U = 0.11$$

Check if the function changes sign between x_L and x_U

$$f(x_L) = f(0) = (0)^3 - 0.165(0)^2 + 3.993\times10^{-4} = 3.993\times10^{-4}$$
$$f(x_U) = f(0.11) = (0.11)^3 - 0.165(0.11)^2 + 3.993\times10^{-4} = -2.662\times10^{-4}$$

Hence

$$f(x_L)f(x_U) = f(0)f(0.11) = \left(3.993\times10^{-4}\right)\left(-2.662\times10^{-4}\right) < 0$$

Therefore, there is at least one root between x_L and x_U , that is between 0 and 0.11.

Iteration 1

The estimate of the root is

$$x_r = \frac{x_U f(x_L) - x_L f(x_U)}{f(x_L) - f(x_U)}$$
$$= \frac{0.11\times3.993\times10^{-4} - 0\times\left(-2.662\times10^{-4}\right)}{3.993\times10^{-4} - \left(-2.662\times10^{-4}\right)}$$
$$= 0.0660$$

$$f(x_r) = f(0.0660)$$
$$= (0.0660)^3 - 0.165(0.0660)^2 + \left(3.993\times10^{-4}\right)$$
$$= -3.1944\times10^{-5}$$

$$f(x_L)f(x_r) = f(0)f(0.0660) = (+)(-) < 0$$

Hence, the root is bracketed between x_L and x_r , that is, between 0 and 0.0660. So, the lower and upper limits of the new bracket are $x_L = 0,\ x_U = 0.0660$, respectively.

Iteration 2

The estimate of the root is

$$x_r = \frac{x_U f(x_L) - x_L f(x_U)}{f(x_L) - f(x_U)}$$
$$= \frac{0.0660 \times 3.993 \times 10^{-4} - 0 \times \left(-3.1944 \times 10^{-5}\right)}{3.993 \times 10^{-4} - \left(-3.1944 \times 10^{-5}\right)}$$
$$= 0.0611$$

The absolute relative approximate error for this iteration is

$$\in_a = \left| \frac{0.0611 - 0.0660}{0.0611} \right| \times 100 \cong 8\%$$

$$f(x_r) = f(0.0611)$$
$$= (0.0611)^3 - 0.165(0.0611)^2 + \left(3.993 \times 10^{-4}\right)$$
$$= 1.1320 \times 10^{-5}$$

$$f(x_L) f(x_r) = f(0) f(0.0611) = (+)(+) > 0$$

Hence, the lower and upper limits of the new bracket are $x_L = 0.0611$, $x_U = 0.0660$, respectively.

Iteration 3

$$x_r = \frac{x_U f(x_L) - x_L f(x_U)}{f(x_L) - f(x_U)}$$

The estimate of the root is $= \frac{0.0660 \times 1.132 \times 10^{-5} - 0.0611 \times \left(-3.1944 \times 10^{-5}\right)}{1.132 \times 10^{-5} - \left(-3.1944 \times 10^{-5}\right)}$

$$= 0.0624$$

The absolute relative approximate error for this iteration is

$$\in_a = \left| \frac{0.0624 - 0.0611}{0.0624} \right| \times 100 \cong 2.05\%$$

$$f(x_r) = -1.1313 \times 10^{-7}$$

$$f(x_L) f(x_r) = f(0.0611) f(0.0624) = (+)(-) < 0$$

Hence, the lower and upper limits of the new bracket are $x_L = 0.0611$, $x_U = 0.0624$

2 marks for each iteration= 6 marks

Relative error - 2 marks for each iteration= 6 marks

Root of $f(x) = x^3 - 0.165x^2 + 3.993 \times 10^{-4} = 0$ for false-position method.

Iteration	x_L	x_U	x_r	$\lvert\epsilon_a\rvert\%$	$f(x_m)$
1	0.0000	0.1100	0.0660	----	-3.1944×10^{-5}
2	0.0000	0.0660	0.0611	8.00	-1.1320×10^{-5}
3	0.0611	0.0660	0.0624	2.05	-1.1313×10^{-7}

c.

//C++ Program

```
#include <iostream>
#include <iomanip>
#include <conio.h>
#include <math.h>
using namespace std;
//define the function for which we want to find the roots
float f (float x)
{
    float fx;
    fx = pow(x,3) - 0.165*pow(x,2)+ 3.993*pow(10,-4);
    return (fx);
}


int main()
{
    float a,b;
    float xprev,xnew;
    float err; //the wanted error tolerance
    float abserr;

    int count = 0;
    cout <<"Enter a = ";
    cin >> a;
    cout <<"Enter b = ";
    cin >> b;
    cout <<"Enter the error tolerance = ";
    cin >> err;
    xprev=a;
    do
    {
        xnew = xprev - (((b - xprev)/(f(b)-f(xprev)))*f(xprev));
      cout << "xprev=" << xprev <<" | b="<< b <<" | xnew=" << xnew <<"
      | " << "  f(xprev)=" << f(xprev) << " |  f(b)=" << f(b) << " |
      f(xnew)=" << f(xnew) << endl << endl;

      abserr=fabs(xnew-xprev)*100;
        xprev=xnew;
        cout<< "The Absolute Error is " << abserr <<endl << endl;
        count++;
    }

    while(count < 3); //condition to stop

      cout << fixed << "The root of the equation is  " <<
      setprecision(4) << xnew << endl << endl;
```

½ mark

1 mark

1 mark

1 mark

1 mark

1 mark

```
        return 0;

    }
```

4a. 2 marks each = 4 marks

- *Forward-substitution* for lower triangular system $\boldsymbol{L}\boldsymbol{x} = \boldsymbol{b}$

$$x_1 = b_1/\ell_{11}, \quad x_i = \left(b_i - \sum_{j=1}^{i-1} \ell_{ij} x_j \right) / \ell_{ii}, \quad i = 2, \ldots, n$$

for $j = 1$ **to** n { loop over columns }
  if $\ell_{jj} = 0$ **then** stop { stop if matrix is singular }
  $x_j = b_j/\ell_{jj}$ { compute solution component }
  for $i = j + 1$ **to** n
    $b_i = b_i - \ell_{ij} x_j$ { update right-hand side }
  end
end

- *Back-substitution* for upper triangular system $\boldsymbol{U}\boldsymbol{x} = \boldsymbol{b}$

$$x_n = b_n/u_{nn}, \quad x_i = \left(b_i - \sum_{j=i+1}^{n} u_{ij} x_j \right) / u_{ii}, \quad i = n-1, \ldots, 1$$

for $j = n$ **to** 1 { loop backwards over columns }
  if $u_{jj} = 0$ **then** stop { stop if matrix is singular }
  $x_j = b_j/u_{jj}$ { compute solution component }
  for $i = 1$ **to** $j - 1$
    $b_i = b_i - u_{ij} x_j$ { update right-hand side }
  end
end

b. 9 marks

suppose $v(t) = a_1 t^2 + a_2 t + a_3, \quad 5 \le t \le 12.$

Results in a matrix template of the form:

$$\begin{bmatrix} t_1^2 & t_1 & 1 \\ t_2^2 & t_2 & 1 \\ t_3^2 & t_3 & 1 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix}$$

From the Table, the matrix becomes:

$$\begin{bmatrix} 25 & 5 & 1 \\ 64 & 8 & 1 \\ 144 & 12 & 1 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} 106.8 \\ 177.2 \\ 279.2 \end{bmatrix}$$

$$\begin{bmatrix} 25 & 5 & 1 \\ 64 & 8 & 1 \\ 144 & 12 & 1 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} 106.8 \\ 177.2 \\ 279.2 \end{bmatrix} \Rightarrow \left[\begin{array}{ccc|c} 25 & 5 & 1 & 106.8 \\ 64 & 8 & 1 & 177.2 \\ 144 & 12 & 1 & 279.2 \end{array}\right]$$

Therefore, using:

1. Forward Elimination
2. Back Substitution

1. Forward elimination

$$\left[\begin{array}{ccc|c} 25 & 5 & 1 & 106.8 \\ 64 & 8 & 1 & 177.2 \\ 144 & 12 & 1 & 279.2 \end{array}\right]$$

Divide Equation 1 by 25 and multiply it by 64, $\frac{64}{25} = 2.56$

$$\left[\begin{array}{ccc|c} 25 & 5 & 1 & 106.8 \end{array}\right] \times 2.56 = \left[\begin{array}{ccc|c} 64 & 12.8 & 2.56 & 273.408 \end{array}\right]$$

Subtract the result from Equation 2

$$\begin{array}{r} \left[\begin{array}{ccc|c} 64 & 8 & 1 & 177.2 \end{array}\right] \\ -\left[\begin{array}{ccc|c} 64 & 12.8 & 2.56 & 273.408 \end{array}\right] \\ \hline \left[\begin{array}{ccc|c} 0 & -4.8 & -1.56 & -96.208 \end{array}\right] \end{array}$$

Substitute new equation for Equation 2

$$\left[\begin{array}{ccc|c} 25 & 5 & 1 & 106.8 \\ 0 & -4.8 & -1.56 & -96.208 \\ 144 & 12 & 1 & 279.2 \end{array}\right]$$

$$\left[\begin{array}{ccc|c} 25 & 5 & 1 & 106.8 \\ 0 & -4.8 & -1.56 & -96.208 \\ 144 & 12 & 1 & 279.2 \end{array}\right]$$ Divide Equation 1 by 25 and multiply it by 144, $\frac{144}{25} = 5.76$

$$\left[\begin{array}{ccc|c} 25 & 5 & 1 & 106.8 \end{array}\right] \times 5.76 = \left[\begin{array}{ccc|c} 144 & 28.8 & 5.76 & 615.168 \end{array}\right]$$

Subtract the result from Equation 3

$$\begin{array}{r} \left[\begin{array}{ccc|c} 144 & 12 & 1 & 279.2 \end{array}\right] \\ -\left[\begin{array}{ccc|c} 144 & 28.8 & 5.76 & 615.168 \end{array}\right] \\ \hline \left[\begin{array}{ccc|c} 0 & -16.8 & -4.76 & -335.968 \end{array}\right] \end{array}$$

Substitute new equation for Equation 3

$$\left[\begin{array}{ccc|c} 25 & 5 & 1 & 106.8 \\ 0 & -4.8 & -1.56 & -96.208 \\ 0 & -16.8 & -4.76 & -335.968 \end{array}\right]$$

$$\left[\begin{array}{ccc|c} 25 & 5 & 1 & 106.8 \\ 0 & -4.8 & -1.56 & -96.208 \\ 0 & -16.8 & -4.76 & -335.968 \end{array}\right]$$ Divide Equation 2 by −4.8 and multiply it by −16.8,

$$\frac{-16.8}{-4.8} = 3.5$$

$$\left[\begin{array}{ccc|c} 0 & -4.8 & -1.56 & -96.208 \end{array}\right] \times 3.5 = \left[\begin{array}{ccc|c} 0 & -16.8 & -5.46 & -336.728 \end{array}\right]$$

$$\begin{array}{r} \left[\begin{array}{ccc|c} 0 & -16.8 & -4.76 & 335.968 \end{array}\right] \\ -\left[\begin{array}{ccc|c} 0 & -16.8 & -5.46 & -336.728 \end{array}\right] \\ \hline \left[\begin{array}{ccc|c} 0 & 0 & 0.7 & 0.76 \end{array}\right] \end{array}$$

Subtract the result from Equation 3

Substitute new equation for Equation 3

$$\left[\begin{array}{cccc:c} 25 & 5 & 1 & \vdots & 106.8 \\ 0 & -4.8 & -1.56 & \vdots & -96.208 \\ 0 & 0 & 0.7 & \vdots & 0.76 \end{array}\right]$$

2. Back substitution

$$\left[\begin{array}{cccc:c} 25 & 5 & 1 & \vdots & 106.8 \\ 0 & -4.8 & -1.56 & \vdots & -96.2 \\ 0 & 0 & 0.7 & \vdots & 0.7 \end{array}\right] \Rightarrow \left[\begin{array}{ccc} 25 & 5 & 1 \\ 0 & -4.8 & -1.56 \\ 0 & 0 & 0.7 \end{array}\right]\left[\begin{array}{c} a_1 \\ a_2 \\ a_3 \end{array}\right] = \left[\begin{array}{c} 106.8 \\ -96.208 \\ 0.76 \end{array}\right]$$

Solving for a_3

$$0.7a_3 = 0.76$$
$$a_3 = \frac{0.76}{0.7}$$
$$a_3 = 1.08571$$

Solving for a_2

$$-4.8a_2 - 1.56a_3 = -96.208$$
$$a_2 = \frac{-96.208 + 1.56a_3}{-4.8}$$
$$a_2 = \frac{-96.208 + 1.56 \times 1.08571}{-4.8}$$
$$a_2 = 19.6905$$

Solving for a_1

$$25a_1 + 5a_2 + a_3 = 106.8$$
$$a_1 = \frac{106.8 - 5a_2 - a_3}{25}$$
$$= \frac{106.8 - 5 \times 19.6905 - 1.08571}{25}$$
$$= 0.290472$$

Therefore,

$$\left[\begin{array}{c} a_1 \\ a_2 \\ a_3 \end{array}\right] = \left[\begin{array}{c} 0.290472 \\ 19.6905 \\ 1.08571 \end{array}\right]$$

From the polynomial equation:

$$v(t) = a_1 t^2 + a_2 t + a_3$$
$$= 0.290472t^2 + 19.6905t + 1.08571, \quad 5 \le t \le 12$$

Therefore,
$$v(6) = 0.290472(6)^2 + 19.6905(6) + 1.08571$$
$$= 129.686 \text{ m/s}.$$

c. $3\frac{1}{2}$ marks

```
#include<iostream>
#include<conio.h>
using namespace std;
int main()
{
    int n,i,j;
    float mult,sum=0,x[10],f[10],a;
    cout<<"Enter no of sample points ? ";
    cin>>n;
    cout<<"Enter all values of x and corresponding funtional value:
"<<endl;
    for(i=0;i<n;i++)
        cin>>x[i]>>f[i];

    cout<<"\nEnter your x for calculation : ";
    cin>>a;

    for(i=0;i<=n-1;i++)
    {
    mult=1;
        for(j=0;j<=n-1;j++)
        {
            if(j!=i)
            mult*=(a-x[j])/(x[i]-x[j]);
        }
        sum+=mult*f[i];
    }
    cout<<"\nThe estimated value of f(x) = "<<sum;
    getch();
    return 0;
}
```

5a. 6 marks

Degree of the interpolating polynomial: $n = 3$.
Nodes: $x_0 = 0, x_1 = 1, x_2 = 2, x_3 = 4$.
Functional values: $f_0 = 7, f_1 = 13, f_2 = 21, f_3 = 43$.

$$L_0(x) = \frac{(x-1)(x-2)(x-4)}{(-1)(-2)(-4)} = \frac{(x-1)(x-2)(x-4)}{-8}$$

$$L_1(x) = \frac{(x-0)(x-2)(x-4)}{1\cdot(-1)(-3)} = \frac{x(x-2)(x-4)}{3}$$

$$L_2(x) = \frac{(x-0)(x-1)(x-4)}{2\cdot 1\cdot(-2)} = \frac{x(x-1)(x-4)}{-4}$$

$$L_3(x) = \frac{(x-0)(x-1)(x-2)}{4\cdot 3\cdot 2} = \frac{x(x-1)(x-2)}{24}$$

$L_0(3) = \frac{1}{4}$, $L_1(3) = -1$, $L_2(3) = \frac{3}{2}$, $L_3(3) = \frac{1}{4}$.

So, $P_3(3) = 7L_0(3) + 13L_1(3) + 21L_2(3) + 43L_3(3) = 31$.

Interpolated value of $f(3) = P_3(3) = 31$.

b. $5^1/_2$marks

Nodes: $x_0 = 1, x_1 = 1.5, x_2 = 2.5$

Functional Values: $f_0 = 0, f_1 = 0.4055, f_2 = 0.9163$

$P_0 = f_0 = 0$.

$$a_0 = f[x_0] = f_0 = 0$$

$$a_1 = f[x_0, x_1] = \frac{f[x_1] - f[x_0]}{x_1 - x_0} = \frac{f_1 - f_0}{x_1 - x_0} = 0.8118$$

$$a_2 = f[x_0, x_1, x_2] = \frac{f[x_1, x_2] - f[x_2, x_1]}{x_2 - x_0}$$

$$= \frac{\frac{f[x_2] - f[x_1]}{x_2 - x_1} - \frac{f[x_1] - f[x_0]}{x_1 - x_0}}{x_2 - x_0}$$

$$= \frac{\frac{f_2 - f_1}{x_2 - x_1} - \frac{f_1 - f_0}{x_1 - x_0}}{x_2 - x_0} = \frac{0 - 5108 - 0.81108}{1.5} = -0.2002$$

Interpolation of $f(1.9)$ using $P_2(x)$:

Let $P_2(x) = a_0 + a_1(x - x_0) + a_2(x - x_0)(x - x_1) = 0.6585$

Accuracy Check: The tabulated values of $f(x)$ correspond to $f(x) = \ln(x)$.

Exact Value of $\ln(1.5) = 0.6419$.

Absolute Error: $|P_2(1.9) - \ln(1.5)| = |0.6585 - 0.6419| = 0.0166$.

c. $5^1/_2$marks

Input Data:

$$\begin{cases} \text{Nodes: } x_0 = 1, x_1 = 1.5, x_2 = 2, x_3 = 3, x_4 = 3.5 \\ \text{Function Values: } f_0 = 1, f_1 = 0.17609, f_2 = 0.30103, f_3 = 0.4772, f_4 = 0.54407 \\ \text{Degrees of the Interpolating Polynomials: } k = 3 \text{ and } k = 4 \end{cases}$$

Formula to be Used: $P_k(x) = P_{k-1}(x) + (x - x_0)(x - x_1)\cdots(x - x_{k-1})f[x_0, x_1, \ldots, x_k], k = 1, 2, 3, 4.$

i	x_i	f_i	$1st$ diff.	$2nd$ diff.	$3rd$ diff.	$4th$ diff.
0	1.0	0				
			0.3522			
1	1.5	0.17609		-0.1023		
			0.2499		0.0265534	
2	2.0	0.30103		−0.0491933		-0.006409
			0.1761		0.01053	
3	3.0	0.47712		−0.0281333		−0.002169
			0.1339		0.005107	
4	3.5	0.54407		−0.01792		
			0.11598			

Set $P_0(x) = f_0 = 0$

$\mathbf{k = 1}$: $P_1(x) = P_0(x) + f[x_0, x_1](x - x_0)$
$= 0 + 0.3522 \times (x - 1)(x - 1.5) = 0.3522(x - 1)$

$\mathbf{k = 2}$: $P_2(x) = P_1(x) + f[x_0, x_1, x_2](x - x_0)(x - x_1)$
$= 0.3522(x - 1) - 0.1023(x - 1)(x - 1.5)$

$\mathbf{k = 3}$: $P_3(x) = P_2(x) + f[x_0, x_1, x_2, x_3](x - x_0)(x - x_1)(x - x_2)$
$= 0.3522(x - 1) - 0.1023(x - 1)(x - 1.5) + 0.0265534(x - 1)(x - 1.5)(x - 2)$

$\mathbf{k = 4}$: $P_4(x) = P_3(x) + f[x_0, x_1, x_2, x_3, x_4](x - x_0)(x - x_1)(x - x_2)(x - x_3)$
$= 0.3522(x - 1) - 0.1023(x - 1)(x - 1.5) + 0.0265534(x - 1)(x - 1.5)(x - 2)$
$-0.006409(x - 1)(x - 1.5)(x - 2)(x - 3)$

$$P_4(2.5) = P_3(2.5) + (2.5 - 1.0)(2.5 - 1.5)(2.5 - 2.0)(2.5 - 3.0)(-.006409)$$
$$= 0.394795 + .002403 = \boxed{0.397198}.$$

6a. $5\frac{1}{2}$marks

RK2 Heun's Method

$$\frac{d\theta}{dt} = -2.2067\times10^{-12}\left(\theta^4 - 81\times10^8\right)$$

$$f(t,\theta) = -2.2067\times10^{-12}\left(\theta^4 - 81\times10^8\right)$$

$$\theta_{i+1} = \theta_i + \left(\frac{1}{2}k_1 + \frac{1}{2}k_2\right)h$$

Step 1: $i = 0, t_0 = 0, \theta_0 = \theta(0) = 1200K$

$$k_1 = f(t_0, \theta_o)$$
$$= f(0,1200)$$
$$= -2.2067\times10^{-12}\left(1200^4 - 81\times10^8\right)$$
$$= -4.5579$$

$$k_2 = f(t_0 + h, \theta_0 + k_1 h)$$
$$= f(0+240, 1200+(-4.5579)240)$$
$$= f(240, 106.09)$$
$$= -2.2067\times10^{-12}\left(106.09^4 - 81\times10^8\right)$$
$$= 0.017595$$

$$\theta_1 = \theta_0 + \left(\frac{1}{2}k_1 + \frac{1}{2}k_2\right)h$$
$$= 1200 + \left(\frac{1}{2}(-4.5579) + \frac{1}{2}(0.017595)\right)240$$
$$= 1200 + (-2.2702)240$$
$$= 655.16K$$

Step 2: $i = 1, t_1 = t_0 + h = 0 + 240 = 240, \theta_1 = 655.16K$

$$k_1 = f(t_1, \theta_1)$$
$$= f(240, 655.16)$$
$$= -2.2067\times10^{-12}\left(655.16^4 - 81\times10^8\right)$$
$$= -0.38869$$

$$k_2 = f(t_1 + h, \theta_1 + k_1 h)$$
$$= f(240+240, 655.16+(-0.38869)240)$$
$$= f(480, 561.87)$$
$$= -2.2067\times10^{-12}\left(561.87^4 - 81\times10^8\right)$$
$$= -0.20206$$

$$\theta_2 = \theta_1 + \left(\frac{1}{2}k_1 + \frac{1}{2}k_2\right)h$$
$$= 655.16 + \left(\frac{1}{2}(-0.38869) + \frac{1}{2}(-0.20206)\right)240$$
$$= 655.16 + (-0.29538)240$$
$$= 584.27K$$

b. RK4 6 marks

Problem:

$$\frac{dy}{dx} = 1 + y + x^2, \qquad y(0) = 0.5$$

Use RK4 to find $y(0.2), y(0.4)$

$h = 0.2$

$f(x,y) = 1 + y + x^2$

$x_0 = 0, \quad y_0 = 0.5$

Fourth Order Runge Kutta (RK4)

$$K_1 = f(x_i, y_i)$$

$$K_2 = f(x_i + \frac{1}{2}h, y_i + \frac{1}{2}K_1 h)$$

$$K_3 = f(x_i + \frac{1}{2}h, y_i + \frac{1}{2}K_2 h)$$

$$K_4 = f(x_i + h, y_i + K_3 h)$$

$$y_{i+1} = y_i + \frac{h}{6}(K_1 + 2K_2 + 2K_3 + K_4)$$

Step1:

$$K_1 = f(x_0, y_0) = 1 + y_0 + x_0^{\,2} = 1.5$$

$$K_2 = f(x_0 + \frac{1}{2}h, y_0 + \frac{1}{2}K_1 h) = 1 + (y_0 + 0.15) + (x_0 + 0.1)^2 = 1.64$$

$$K_3 = f(x_0 + \frac{1}{2}h, y_0 + \frac{1}{2}K_2 h) = 1 + (y_0 + 0.164) + (x_0 + 0.1)^2 = 1.654$$

$$K_4 = f(x_0 + h, y_0 + K_3 h) = 1 + (y_0 + 0.16545) + (x_0 + 0.2)^2 = 1.7908$$

$$y_1 = y_0 + \frac{h}{6}(K_1 + 2K_2 + 2K_3 + K_4) = 0.8293$$

Step 2:

$$K_1 = f(x_1, y_1) = 1.7893$$

$$K_2 = f(x_1 + \frac{1}{2}h, y_1 + \frac{1}{2}K_1 h) = 1.9182$$

$$K_3 = f(x_1 + \frac{1}{2}h, y_1 + \frac{1}{2}K_2 h) = 1.9311$$

$$K_4 = f(x_1 + h, y_1 + K_3 h) = 2.0555$$

$$y_2 = y_1 + \frac{0.2}{6}(K_1 + 2K_2 + 2K_3 + K_4) = 1.2141$$

i	x_i	y_i
0	0.0	0.5
1	0.2	0.8293
2	0.4	1.2141

c. 6 marks

Euler's Method

$$\frac{dx}{dt} = 37.5 - 3.5x$$

$$f(t, x) = 37.5 - 3.5x$$

The Euler's method reduces to

$$x_{i+1} = x_i + f(t_i, x_i)h$$

For $i = 0,\ t_0 = 0,\ x_0 = 50$

$$x_1 = x_0 + f(t_0, x_0)h$$

$$= 50 + f(0,50)1.5$$

$$= 50 + (37.5 - 3.5(50))1.5$$
$$= 50 + (-137.5)1.5$$
$$= -156.25 \text{g/L}$$

x_1 is the approximate concentration of salt at

$$t = t_1 = t_0 + h = 0 + 1.5 = 1.5 \text{ min}$$
$$x(1.5) \approx x_1 = -156.25 \text{ g/L}$$

For $i = 1$, $t_1 = 1.5$, $x_1 = -156.25$

$$x_2 = x_1 + f(t_1, x_1)h$$
$$= -156.25 + f(1.5, -156.25)1.5$$
$$= -156.25 + (37.5 - 3.5(-156.25))1.5$$
$$= -156.25 + (584.38)1.5$$
$$= 720.31 \text{ g/L}$$

x_2 is the approximate concentration of salt at

$$t = t_2 = t_1 + h = 1.5 + 1.5 = 3 \text{ min}$$
$$x(3) \approx x_2 = 720.31 \text{ g/L}$$

COVENANT UNIVERSITY

CANAANLAND, KM 10, IDIROKO ROAD
P.M.B 1023, OTA, OGUN STATE, NIGERIA.

TITLE OF EXAMINATION: B.Sc EXAMINATION
COLLEGE: College of Science and Technology
SCHOOL: School of Natural & Applied Sciences
DEPARTMENT: Department of Computer and Information Sciences
SESSION: 2014/2015 **SEMESTER:** ALPHA
COURSE CODE: CSC 431 **CREDIT UNIT:** 3
COURSE TITLE: Computational Science & Numerical Methods
INSTRUCTION: Answer ANY 4 questions **TIME:** 3 HOURS

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1. (a) Write a PYTHON program to find the root of the function f(x) = e^x (3.2 sin(x) - 0.5cos(x)) on the interval [3, 4] using the bisection method with an error tolerance of 0.001. Your program should output a, b, f(a), f(b), c, f(c) in a tabular form. (4 marks)
   (b) Find the Lagrange Interpolating polynomial P_3 through the points (0, 3), (1, 2), (2, 7), and (4, 59), and then approximate value f (3) by $P_3(3)$. ($5^1/_2$marks)
   (c) Given $f(x) = -0.67665 \times 10^{-8} x^4 - 0.26689 \times 10^{-5} x^3 + 0.12748 \times 10^{-3} x^2 - 0.018507 = 0$ with initial values $x_{-1} = 10$ and $x_0 = 15$.
      i. Conduct three iterations using the secant method to find the root of the equation. (6 marks)
      ii. Find the absolute relative error at the end of each iteration. (2 marks)

2. Determine the root of the function f(x) = $x^3 - e^{-0.5x}$
   (a). Using the bisection method. Start with $a = 0$ and $b = 1$, and carry out the first four iterations. ($5^1/_2$marks)
   (b) Using the secant method. Start with the two points, $x_1 = 0$, and $x_2 = 1$, and carry out the first four iterations. (6 marks)
   (c) Using Newton's method. Start at $x_1 = 1$ and carry out the first four iterations. (6 marks)

3. (a) Given a function f(x) = cos(x) – x, estimate its root in [0,1] using false position's methods for three iterations. (6 marks)
   (b) Find the percentage relative error for each iteration in 1a above. ($5^1/_2$ marks)
   (c) Compute ln 9.2 from ln 9.0 = 2.1972, ln 9.5 = 2.2513 and ln 11.0 = 2.3979 by the Lagrange interpolation and determine the error from ln 9.2 = 2.2192. (6 marks)

4. (a) Give the pseudocodes for Guassian elimination method s. (5 marks)
   (b) The upward velocity of a rocket is given at three different times in Table below:

Velocity vs. time data.

Time, t (s)	Velocity, v (m/s)
5	106.8
8	177.2
12	279.2

The velocity data is approximated by a polynomial as $v(t) = a_1 t^2 + a_2 t + a_3$, $5 \le t \le 12$

The coefficients $a_1, a_2,$ and a_3 for the above expression are given by

$$\begin{bmatrix} 25 & 5 & 1 \\ 64 & 8 & 1 \\ 144 & 12 & 1 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} 106.8 \\ 177.2 \\ 279.2 \end{bmatrix}$$

Find the values of $a_1, a_2,$ and a_3 using the Naïve Gauss elimination method. Find the velocity at $t = 6, 7.5, 9, 11$ seconds. (9 marks)

(c) What are the different numerical methods for finding the roots of an equation? Comment on each one in terms of its conditions and rate of convergence. (5½ marks)

5. (a) Using the following table;

0	7
1	13
2	21
4	43

iii. Explicitly construct the Lagrange Interpolating polynomial $P_3(x)$.

iv. Interpolate f(3) (6 marks)

(b) Given the following table of values:

x	1	1.5	2.5
$f(x)$	0	0.4055	0.9163

iii. Compute the coefficients of the Newton interpolating polynomial $P_2(x)$ using divided differences.

iv. Interpolate f(1.9). (5½marks)

(c) Given the following table:

x	1	1.5	2	3	3.5
$f(x)$	0	0.17609	0.30103	0.4772	0.54407

i. Construct the table of divided differences.

ii. Using the divided differences, construct $P_4(x)$ and interpolate f(2.5).(6 marks)

6. (a) A ball of 1200K is allowed to cool down in air at an ambient temperature of 300K. Assuming heat is lost only due to radiation, the differential equation for the temperature of the ball is given by;

$$\frac{d\theta}{dt} = -2.2067x10^{-12}(\theta^4 - 81x10^8) \qquad \theta(0) = 1200K$$

Find the temperature at t = 480 seconds using RK2 Heun's method. Assume a step size of h = 240 seconds. ($5^{1}/_{2}$ marks)

(b) Given that $\frac{dy}{dx} = 1 + y + x^2$ and $y(0) = 0.5$. Using RK4 and a step size of 0.2, find $y(0.4)$. (6 marks)

(c) The concentration of salt in a homemade soap maker is given as a function of time by

$$\frac{dx}{dt} = 37.5 - 3.5x$$

At the initial time, t=0, the salt concentration in the tank is 50 g/L. Using RK2 Euler's method and a step size of h=1.5, what is the salt concentration after 3 minutes? (6 marks)

B.Sc. (Hons). Degree 2014/ 2015 Alpha Semester Examination
Course Code: CSC 431 Units: 3units
Course Title: Computational Science & Numerical Methods

Marking Scheme

1a.

#Python Program to find roots of f(x) = e^{-x} (3.2 sin(x) - 0.5cos(x)) using the bisection method

```
import math
# a and b are the endpoints of the interval [a,b] where our function func is defined.
a = 3.0
b = 4.0
i = 1 #iteration counter
# the wanted error tolerance, err
err = 0.001
# define the function for which we want to find the roots
def func(x):
   FX = math.exp(-x)*((3.2*math.sin(x)) - (0.5*math.cos(x)))
   return FX
c = (a+b)/2.0 # computes midpoint
while abs(func(c)) > err:
   print i,'\t',a,'\t',b,'\t',func(a),'\t',func(b),'\t',c,'\t',func(c)
   if func(a)*func(c) < 0: #root in the left half
      b = c
   else:                #root in the right half
      a = c

   i += 1
   c = (a+b)/2.0 # computes the next midpoint
print "\nThe root of the equation is: %.4f" % c
```

b.

$$L_0(x) = \frac{(x-1)(x-2)(x-4)}{(0-1)(0-2)(0-4)} = -\frac{1}{8}(x^3 - 7x^2 + 14x - 8)$$

$$L_1(x) = \frac{(x-0)(x-2)(x-4)}{(1-0)(1-2)(1-4)} = \frac{1}{3}(x^3 - 6x^2 + 8x)$$

$$L_2(x) = \frac{(x-0)(x-1)(x-4)}{(2-0)(2-1)(2-4)} = -\frac{1}{4}(x^3 - 5x^2 + 4x)$$

$$L_3(x) = \frac{(x-0)(x-1)(x-2)}{(4-0)(4-1)(4-2)} = \frac{1}{24}(x^3 - 3x^2 + 2x)$$

$$P_3(x) = -\tfrac{3}{8}(x^3 - 7x^2 + 14x - 8) + \tfrac{3}{4}(x^3 - 6x^2 + 8x)$$
$$- \tfrac{7}{4}(x^3 - 5x^2 + 4x) + \tfrac{59}{24}(x^3 - 3x^2 + 2x)$$
$$= \tfrac{1}{24}(-9x^3 + 63x^2 - 126x + 72 + 16x^3 - 96x^2 + 128x$$
$$-42x^3 + 210x^2 - 168x + 59x^3 - 177x^2 + 118x)$$
$$= \tfrac{1}{24}(24x^3 + 0x^2 - 48x + 72)$$
$$= x^3 - 2x + 3$$

$p_3(x) = \chi 2 - 2\chi + 3$

$f(3) \approx p_3(3) = 27 - 6 + 3 = 24$

c.

i. Iteration 1

The estimate of the root is

$$x_1 = x_0 - \frac{f(x_0)(x_0 - x_{-1})}{f(x_0) - f(x_{-1})}$$

$$f(x_0) = -0.67665\times10^{-8}x_0^4 - 2.6689\times10^{-5}x_0^3 + 0.12748\times10^{-3}x_0^2 - 0.018507$$
$$= -0.67665\times10^{-8}(15)^4 - 2.6689\times10^{-5}(15)^3 + 0.12748\times10^{-3}(15)^2 - 0.018507$$
$$= 8.2591\times10^{-4}$$

$$f(x_{-1}) = -0.67665\times10^{-8}x_{-1}^4 - 2.6689\times10^{-5}x_{-1}^3 + 0.12748\times10^{-3}x_{-1}^2 - 0.018507$$
$$= -0.67665\times10^{-8}(10)^4 - 2.6689\times10^{-5}(10)^3 + 0.12748\times10^{-3}(10)^2 - 0.018507$$
$$= -8.4956\times10^{-3}$$

$$x_1 = 15 - \frac{(8.2591\times10^{-4})(15-10)}{(8.2591\times10^{-4}) - (-8.4956\times10^{-3})}$$
$$= 14.557$$

Iteration 2

The estimate of the root is

$$x_2 = x_1 - \frac{f(x_1)(x_1 - x_0)}{f(x_1) - f(x_0)}$$

$$f(x_1) = -0.67665\times10^{-8}x_1^4 - 2.6689\times10^{-5}x_1^3 + 0.12748\times10^{-3}x_1^2 - 0.018507$$
$$= -0.67665\times10^{-8}(14.557)^4 - 2.6689\times10^{-5}(14.557)^3 + 0.12748\times10^{-3}(14.557)^2 - 0.018507$$
$$= -2.9870\times10^{-5}$$

$$x_2 = 15 - \frac{(-2.9870\times10^{-5})(14.557-15)}{(-2.9870\times10^{-5}) - (8.2591\times10^{-4})}$$
$$= 14.572$$

Iteration 3

The estimate of the root is

$$x_3 = x_2 - \frac{f(x_2)(x_2 - x_1)}{f(x_2) - f(x_1)}$$

$$\begin{aligned} f(x_2) &= -0.67665\times10^{-8}x_2^4 - 2.6689\times10^{-5}x_2^3 + 0.12748\times10^{-3}x_2^2 - 0.018507 \\ &= -0.67665\times10^{-8}(14.572)^4 - 2.6689\times10^{-5}(14.572)^3 + 0.12748\times10^{-3}(14.572)^2 - 0.018507 \\ &= -6.0676\times10^{-9} \end{aligned}$$

$$x_2 = 14.572 - \frac{(-6.0676\times10^{-9})(14.572-14.557)}{(-6.0676\times10^{-9})-(-2.9870\times10^{-5})}$$

ii. $= 14.572$

The absolute relative approximate error $|\in_a|$ at the end of Iteration 1 is

$$\begin{aligned} |\in_a| &= \left|\frac{x_1 - x_0}{x_1}\right|\times100 \\ &= \left|\frac{14.557-15}{14.557}\right|\times100 \\ &= 3.0433\% \end{aligned}$$

The absolute relative approximate error $|\in_a|$ at the end of Iteration 2 is

$$\begin{aligned} |\in_a| &= \left|\frac{x_2 - x_1}{x_2}\right|\times100 \\ &= \left|\frac{14.572-14.557}{14.572}\right|\times100 \\ &= 0.10611\% \end{aligned}$$

The absolute relative approximate error $|\in_a|$ at the end of Iteration 3 is

$$\begin{aligned} |\in_a| &= \left|\frac{x_2 - x_1}{x_2}\right|\times100 \\ &= \left|\frac{14.572-14.572}{14.572}\right|\times100 \\ &= 2.1559\times10^{-5}\% \end{aligned}$$

2. Using five significant digits

(a) $x^3 - e^{-0.5x}$

i = 1, a = 0, b = 1, f(0) = $0^3 - e^{-0.5(0)} = -1$, f(1) = $1^3 - e^{-0.5(1)} = 0.39347$,

$x_{NSI} = \frac{0+1}{2} = 0.5$

f(0.5) = $0.5^3 - e^{0.5(0.5)} = -0.6538$

i = 2, a = 0.5, b = 1, $x_{NS2} = \frac{0.5+1}{2} = 0.75$, f(0.75) = $0.75^3 - e^{-0.5(0.75)} = -0.26541$

i = 3, a = 0.75, b = 1, $x_{NS3} = \frac{0.75+1}{2} = 0.875$, f(0.875) = $0.875^3 - e^{-0.5(0.875)} = 0.024273$

i = 4, a = 0.75, b = 0.875, $x_{NS4} = \frac{0.75+0.85}{2} = 0.8125$,

f(0.8125) = $0.8125^3 - e^{-0.5(0.8125)} = -0.12977$

(b) $x_{i+1} = x_i - \frac{f(x_i)(x_{i-1}-x_i)}{f(x_{i-1})-f(x_i)}$

$x_1 = 0, x_2 = 1, f(x_1) = 0^3 - e^{-0.5(0)} = -1, f(x_2) = 1^3 - e^{-0.5(1)} = 0.39347$

$i = 2 \quad x_3 = 1 - \frac{0.39347(0-1)}{(-1)-0.39347} = 0.71763, f(x_3) = 0.71763^3 - e^{-0.5(0.71763)}$

$= -0.32894$

$i = 3 \quad x_4 = 0.71763 - \frac{(-0.32894(1-0.71763)}{0.39347-(-0.32894)} = 0.84620, f(x_4)$

$= 0.84620^3 - e^{-0.5(0.84620)} = -0.049088$

$i = 4 \quad x_5 = 0.84620 - \frac{(0.049088)(0.71763-0.84620)}{(-0.32894)-(-0.049088)} = 0.86875, f(x_5)$

$= 0.86875^3 - e^{-0.5(0.86875)} = 0.0079994$

$i = 5 \quad x_6 = 0.86875 - \frac{0.0079994(0.84620-0.86875)}{(-0.049088)-0.0079994} = 0.86559$

(c) $f(x) = x^3 - e^{-0.5x}, f' = 3x^2 + 0.5e^{-0.5x}, x_{i+1} = x_i - \frac{f(x_i)}{f'(x_i)} = x_i -$

$\frac{x^3-e^{-0.5x}}{3x^2+0.5e^{-0.5x}}$

$i = 1, \quad x_1 = 1, x_2 = 1 - \frac{1^3 - e^{-0.5(1)}}{3(1^2)+0.5e^{-0.5(1)}} = 0.88088$

$i = 2, \quad x_3 = 0.88088 - \frac{0.88088^3 - e^{-0.5(0.88088)}}{3(0.88088^2)+0.5e^{-0.5(0.88088)}} = 0.86618$

$i = 3, \quad x_4 = 0.86618 - \frac{0.86618^3 - e^{-0.5(0.86618)}}{3(0.86618^2)+0.5e^{-0.5(0.86618)}} = 0.86565$

$$i = 4, \quad x_5 = 0.86565 - \frac{0.86565^3 - e^{-0.5(0.86565)}}{3(0.86565^2) + 0.5e^{-0.5(0.86565)}} = 0.86565$$

3a.

Let $f(x) = \cos x - x$. For the first iteration, we have $(a_1, b_1) = (0, 1)$ and we know that $f(a_1) = 1 > 0$ and that $f(b_1) = \cos 1 - 1 \approx -0.460 < 0$. Our first approximation to the location of the root is

$$p_1 = b_1 - f(b_1)\frac{b_1 - a_1}{f(b_1) - f(a_1)} = 0.685073357.$$

To determine whether the root is contained on (a_1, p_1) or on (p_1, b_1), we calculate $f(p_1) \approx 0.0893 > 0$. Since $f(a_1)$ and $f(p_1)$ are of the same sign, the Intermediate Value Theorem tells us that root is between p_1 and b_1. For the next iteration, we therefore take $(a_2, b_2) = (p_1, b_1) = (0.685073357, 1)$. Our second approximation to the location of the root is

$$p_2 = b_2 - f(b_2)\frac{b_2 - a_2}{f(b_2) - f(a_2)} = 0.736298998.$$

Note that $f(p_2) \approx 0.00466 > 0$, which is of the same sign as $f(a_2)$. Hence, the Intermediate Value Theorem tells us the root is between p_2 and b_2, so we take $(a_3, b_3) = (p_2, b_2) = (0.736298998, 1)$. In the third iteration, we calculate

$$p_3 = b_3 - f(b_3)\frac{b_3 - a_3}{f(b_3) - f(a_3)} = 0.738945356$$

and $f(p_3) \approx 2.339 \times 10^{-4} < 0$. Hence, we find that $f(a_3)$ and $f(p_3)$ are of the same sign, which implies that the root lies somewhere between p_3 and b_3. For the fourth iteration, we will therefore take $(a_4, b_4) = (p_3, b_3) = (0.738945356, 1)$.

b. Absolute relative error is

$$|\epsilon_a| = \left|\frac{x_{i+1} - x_i}{x_{i+1}}\right| \times 100$$

1st Iteration – 100%
2nd Iteration - 6.9572%
3rd Iteration - 0.3581%

c.

Given (x_0, f_0), (x_1, f_1), and (x_2, f_2) we set

$$L_0(x) = \frac{l_0(x)}{l_0(x_0)} = \frac{(x - x_1)(x - x_2)}{(x_0 - x_1)(x_0 - x_2)},$$

$$L_1(x) = \frac{l_1(x)}{l_1(x_1)} = \frac{(x-x_0)(x-x_2)}{(x_1-x_0)(x_1-x_2)},$$

$$L_2(x) = \frac{l_2(x)}{l_2(x_2)} = \frac{(x-x_0)(x-x_1)}{(x_2-x_0)(x_2-x_1)},$$

$$p_2(x) = L_0(x)f_0 + L_1(x)f_1 + L_2(x)f_2.$$

χ_0= 9.0, χ_1= 9.5, χ_2= 11.0, f_0= 2.1972, and f_1= 2.2513, f_2= 2.3979.

$$L_0(x) = \frac{(x-9.5)(x-11.0)}{(9.0-9.5)(9.0-11.0)} = x^2 - 20.5x + 104.5, \quad L_0(9.2) = 0.5400;$$

$$L_1(x) = \frac{(x-9.0)(x-11.0)}{(9.5-9.0)(9.5-11.0)} = \frac{1}{0.75}(x^2 - 20x + 99), \quad L_1(9.2) = 0.4800;$$

$$L_2(x) = \frac{(x-9.0)(x-9.5)}{(11.0-9.0)(11.0-9.5)} = \frac{1}{3}(x^2 - 18.5x + 85.5), \quad L_2(9.2) = -0.0200$$

$$\ln 9.2 \approx p_2(9.2) = L_0(9.2)f_0 + L_1(9.2)f_1 + L_2(9.2)f_2 =$$

$$0.5400 \cdot 2.1972 + 0.4800 \cdot 2.2513 - 0.0200 \cdot 2.3979 = 2.2192,$$

with an actual error

$$\epsilon = 2.21920 - 2.21885 = 0.00035$$

4a.

- *Forward-substitution* for lower triangular system $\boldsymbol{Lx} = \boldsymbol{b}$

$$x_1 = b_1/\ell_{11}, \quad x_i = \left(b_i - \sum_{j=1}^{i-1} \ell_{ij} x_j \right) / \ell_{ii}, \quad i = 2, \ldots, n$$

```
for j = 1 to n                    { loop over columns }
    if ℓ_jj = 0 then stop         { stop if matrix is singular }
    x_j = b_j/ℓ_jj                { compute solution component }
    for i = j + 1 to n
        b_i = b_i − ℓ_ij x_j      { update right-hand side }
    end
end
```

- *Back-substitution* for upper triangular system $\boldsymbol{U}\boldsymbol{x} = \boldsymbol{b}$

$$x_n = b_n/u_{nn}, \quad x_i = \left(b_i - \sum_{j=i+1}^{n} u_{ij} x_j \right) / u_{ii}, \quad i = n-1, \ldots, 1$$

```
for j = n to 1                    { loop backwards over columns }
    if u_jj = 0 then stop         { stop if matrix is singular }
    x_j = b_j / u_jj              { compute solution component }
    for i = 1 to j - 1
        b_i = b_i - u_ij x_j      { update right-hand side }
    end
end
```

b.

suppose $v(t) = a_1 t^2 + a_2 t + a_3, \quad 5 \le t \le 12.$

Results in a matrix template of the form:

$$\begin{bmatrix} t_1^2 & t_1 & 1 \\ t_2^2 & t_2 & 1 \\ t_3^2 & t_3 & 1 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix}$$

From the Table, the matrix becomes:

$$\begin{bmatrix} 25 & 5 & 1 \\ 64 & 8 & 1 \\ 144 & 12 & 1 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} 106.8 \\ 177.2 \\ 279.2 \end{bmatrix}$$

$$\begin{bmatrix} 25 & 5 & 1 \\ 64 & 8 & 1 \\ 144 & 12 & 1 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} 106.8 \\ 177.2 \\ 279.2 \end{bmatrix} \Rightarrow \left[\begin{array}{ccc:c} 25 & 5 & 1 & 106.8 \\ 64 & 8 & 1 & 177.2 \\ 144 & 12 & 1 & 279.2 \end{array}\right]$$

Therefore, using:

3. Forward Elimination
4. Back Substitution

2. Forward elimination

$$\left[\begin{array}{ccc:c} 25 & 5 & 1 & 106.8 \\ 64 & 8 & 1 & 177.2 \\ 144 & 12 & 1 & 279.2 \end{array}\right]$$

Divide Equation 1 by 25 and multiply it by 64, $\dfrac{64}{25} = 2.56$

$$\left[\begin{array}{ccc:c} 25 & 5 & 1 & 106.8 \end{array}\right] \times 2.56 = \left[\begin{array}{ccc:c} 64 & 12.8 & 2.56 & 273.408 \end{array}\right]$$

Subtract the result from Equation 2

$$\begin{array}{r} \left[\begin{array}{ccc:c} 64 & 8 & 1 & 177.2 \end{array}\right] \\ -\left[\begin{array}{ccc:c} 64 & 12.8 & 2.56 & 273.408 \end{array}\right] \\ \hline \left[\begin{array}{ccc:c} 0 & -4.8 & -1.56 & -96.208 \end{array}\right] \end{array}$$

Substitute new equation for Equation 2

$$\begin{bmatrix} 25 & 5 & 1 & \vdots & 106.8 \\ 0 & -4.8 & -1.56 & \vdots & -96.208 \\ 144 & 12 & 1 & \vdots & 279.2 \end{bmatrix}$$

$$\begin{bmatrix} 25 & 5 & 1 & \vdots & 106.8 \\ 0 & -4.8 & -1.56 & \vdots & -96.208 \\ 144 & 12 & 1 & \vdots & 279.2 \end{bmatrix}$$

Divide Equation 1 by 25 and multiply it by 144, $\frac{144}{25} = 5.76$

$$\begin{bmatrix} 25 & 5 & 1 & \vdots & 106.8 \end{bmatrix} \times 5.76 = \begin{bmatrix} 144 & 28.8 & 5.76 & \vdots & 615.168 \end{bmatrix}$$

Subtract the result from Equation 3

$$\begin{array}{r} \begin{bmatrix} 144 & 12 & 1 & \vdots & 279.2 \end{bmatrix} \\ -\begin{bmatrix} 144 & 28.8 & 5.76 & \vdots & 615.168 \end{bmatrix} \\ \hline \begin{bmatrix} 0 & -16.8 & -4.76 & \vdots & -335.968 \end{bmatrix} \end{array}$$

Substitute new equation for Equation 3

$$\begin{bmatrix} 25 & 5 & 1 & \vdots & 106.8 \\ 0 & -4.8 & -1.56 & \vdots & -96.208 \\ 0 & -16.8 & -4.76 & \vdots & -335.968 \end{bmatrix}$$

$$\begin{bmatrix} 25 & 5 & 1 & \vdots & 106.8 \\ 0 & -4.8 & -1.56 & \vdots & -96.208 \\ 0 & -16.8 & -4.76 & \vdots & -335.968 \end{bmatrix}$$

Divide Equation 2 by −4.8 and multiply it by −16.8,

$$\frac{-16.8}{-4.8} = 3.5$$

$$\begin{bmatrix} 0 & -4.8 & -1.56 & \vdots & -96.208 \end{bmatrix} \times 3.5 = \begin{bmatrix} 0 & -16.8 & -5.46 & \vdots & -336.728 \end{bmatrix}$$

Subtract the result from Equation 3

$$\begin{array}{r} \begin{bmatrix} 0 & -16.8 & -4.76 & \vdots & 335.968 \end{bmatrix} \\ -\begin{bmatrix} 0 & -16.8 & -5.46 & \vdots & -336.728 \end{bmatrix} \\ \hline \begin{bmatrix} 0 & 0 & 0.7 & \vdots & 0.76 \end{bmatrix} \end{array}$$

Substitute new equation for Equation 3

$$\begin{bmatrix} 25 & 5 & 1 & \vdots & 106.8 \\ 0 & -4.8 & -1.56 & \vdots & -96.208 \\ 0 & 0 & 0.7 & \vdots & 0.76 \end{bmatrix}$$

2. Back substitution

$$\begin{bmatrix} 25 & 5 & 1 & \vdots & 106.8 \\ 0 & -4.8 & -1.56 & \vdots & -96.2 \\ 0 & 0 & 0.7 & \vdots & 0.7 \end{bmatrix} \Rightarrow \begin{bmatrix} 25 & 5 & 1 \\ 0 & -4.8 & -1.56 \\ 0 & 0 & 0.7 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} 106.8 \\ -96.208 \\ 0.76 \end{bmatrix}$$

$$0.7a_3 = 0.76$$

$$a_3 = \frac{0.76}{0.7}$$

$$a_3 = 1.08571$$

Solving for a_3

Solving for a_2

$$-4.8a_2 - 1.56a_3 = -96.208$$

$$a_2 = \frac{-96.208 + 1.56a_3}{-4.8}$$

$$a_2 = \frac{-96.208 + 1.56 \times 1.08571}{-4.8}$$

$$a_2 = 19.6905$$

Solving for a_1

$$25a_1 + 5a_2 + a_3 = 106.8$$

$$a_1 = \frac{106.8 - 5a_2 - a_3}{25}$$

$$= \frac{106.8 - 5 \times 19.6905 - 1.08571}{25}$$

$$= 0.290472$$

Therefore,

$$\begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} 0.290472 \\ 19.6905 \\ 1.08571 \end{bmatrix}$$

From the polynomial equation:

$$v(t) = a_1 t^2 + a_2 t + a_3$$

$$= 0.290472t^2 + 19.6905t + 1.08571, \quad 5 \le t \le 12$$

Therefore,

$$v(6) = 0.290472(6)^2 + 19.6905(6) + 1.08571$$

$$= 129.686 \text{ m/s.}$$

c. **Bisection Method**

Condition: Continous function f(x) in [a,b] satisfying f(a)f(b) < 0

Convergence: Slow but sure. Linear

False position Method

Condition: Continous function f(x) in [a,b] satisfying f(a)f(b) < 0

Convergence: Slow (linear)

Newton's Method

Condition: Existence of non zero f ´(x)

Convergence: Fast (quadratic)

Secant Method

Condition: Existence of non zero f (x_{n+1}) – f(x_n)
Convergence: Fast (quadratic)

5a.

Degree of the interpolating polynomial: $n = 3$.
Nodes: $x_0 = 0, x_1 = 1, x_2 = 2, x_3 = 4$.
Functional values: $f_0 = 7, f_1 = 13, f_2 = 21, f_3 = 43$.

$$L_0(x) = \frac{(x-1)(x-2)(x-4)}{(-1)(-2)(-4)} = \frac{(x-1)(x-2)(x-4)}{-8}$$

$$L_1(x) = \frac{(x-0)(x-2)(x-4)}{1\cdot(-1)(-3)} = \frac{x(x-2)(x-4)}{3}$$

$$L_2(x) = \frac{(x-0)(x-1)(x-4)}{2\cdot 1\cdot(-2)} = \frac{x(x-1)(x-4)}{-4}$$

$$L_3(x) = \frac{(x-0)(x-1)(x-2)}{4\cdot 3\cdot 2} = \frac{x(x-1)(x-2)}{24}$$

$L_0(3) = \frac{1}{4}$, $L_1(3) = -1$, $L_2(3) = \frac{3}{2}$, $L_3(3) = \frac{1}{4}$.

So, $P_3(3) = 7L_0(3) + 13L_1(3) + 21L_2(3) + 43L_3(3) = 31$.

Interpolated value of $f(3) = P_3(3) = 31$.

b.

Nodes: $x_0 = 1, x_1 = 1.5, x_2 = 2.5$
Functional Values: $f_0 = 0, f_1 = 0.4055, f_2 = 0.9163$
$P_0 = f_0 = 0$.

$$\begin{aligned} a_0 &= f[x_0] = f_0 = 0 \\ a_1 &= f[x_0, x_1] = \frac{f[x_1] - f[x_0]}{x_1 - x_0} = \frac{f_1 - f_0}{x_1 - x_0} = 0.8118 \\ a_2 &= f[x_0, x_1, x_2] = \frac{f[x_1, x_2] - f[x_2, x_1]}{x_2 - x_0} \\ &= \frac{\frac{f[x_2] - f[x_1]}{x_2 - x_1} - \frac{f[x_1] - f[x_0]}{x_1 - x_0}}{x_2 - x_0} \\ &= \frac{\frac{f_2 - f_1}{x_2 - x_1} - \frac{f_1 - f_0}{x_1 - x_0}}{x_2 - x_0} = \frac{0 - 5108 - 0.81108}{1.5} = -0.2002 \end{aligned}$$

Interpolation of $f(1.9)$ using $P_2(x)$:

Let $P_2(x) = a_0 + a_1(x - x_0) + a_2(x - x_0)(x - x_1) = 0.6585$

Accuracy Check: The tabulated values of $f(x)$ correspond to $f(x) = \ln(x)$.

Exact Value of $\ln(1.5) = 0.6419$.

Absolute Error: $|P_2(1.9) - \ln(1.5)| = |0.6585 - 0.6419| = 0.0166$.

c.

Input Data:

$$\begin{cases} \text{Nodes: } x_0 = 1, x_1 = 1.5, x_2 = 2, x_3 = 3, x_4 = 3.5 \\ \text{Function Values: } f_0 = 1, f_1 = 0.17609, f_2 = 0.30103, f_3 = 0.4772, f_4 = 0.54407 \\ \text{Degrees of the Interpolating Polynomials: } k = 3 \text{ and } k = 4 \end{cases}$$

Formula to be Used: $P_k(x) = P_{k-1}(x) + (x - x_0)(x - x_1)\cdots(x - x_{k-1})f[x_0, x_1, \ldots, x_k], k = 1, 2, 3, 4.$

i	x_i	f_i	$1st$ diff.	$2nd$ diff.	$3rd$ diff.	$4th$ diff.
0	1.0	0				
			$\boxed{0.3522}$			
1	1.5	0.17609		$\boxed{-0.1023}$		
			0.2499		$\boxed{0.0265534}$	
2	2.0	0.30103		-0.0491933		$\boxed{-0.006409}$
			0.1761		0.01053	
3	3.0	0.47712		-0.0281333		-0.002169
			0.1339		0.005107	
4	3.5	0.54407		-0.01792		
			0.11598			

Set $P_0(x) = f_0 = 0$

k = 1 : $P_1(x) = P_0(x) + f[x_0, x_1](x - x_0)$
$= 0 + 0.3522 \times (x - 1)(x - 1.5) = 0.3522(x - 1)$

k = 2 : $P_2(x) = P_1(x) + f[x_0, x_1, x_2](x - x_0)(x - x_1)$
$= 0.3522(x - 1) - 0.1023(x - 1)(x - 1.5)$

k = 3 : $P_3(x) = P_2(x) + f[x_0, x_1, x_2, x_3](x - x_0)(x - x_1)(x - x_2)$
$= 0.3522(x - 1) - 0.1023(x - 1)(x - 1.5) + 0.0265534(x - 1)(x - 1.5)(x - 2)$

k = 4 : $P_4(x) = P_3(x) + f[x_0, x_1, x_2, x_3, x_4](x - x_0)(x - x_1)(x - x_2)(x - x_3)$
$= 0.3522(x - 1) - 0.1023(x - 1)(x - 1.5) + 0.0265534(x - 1)(x - 1.5)(x - 2)$
$-0.006409(x - 1)(x - 1.5)(x - 2)(x - 3)$

$$P_4(2.5) = P_3(2.5) + (2.5 - 1.0)(2.5 - 1.5)(2.5 - 2.0)(2.5 - 3.0)(-.006409)$$
$$= 0.394795 + .002403 = \boxed{0.397198}.$$

6a. RK2 Heun's Method

$$\frac{d\theta}{dt} = -2.2067\times10^{-12}\left(\theta^4 - 81\times10^8\right)$$

$$f(t,\theta) = -2.2067\times10^{-12}\left(\theta^4 - 81\times10^8\right)$$

$$\theta_{i+1} = \theta_i + \left(\frac{1}{2}k_1 + \frac{1}{2}k_2\right)h$$

Step 1: $i = 0, t_0 = 0, \theta_0 = \theta(0) = 1200K$

$$k_1 = f(t_0, \theta_o)$$
$$= f(0,1200)$$
$$= -2.2067\times10^{-12}\left(1200^4 - 81\times10^8\right)$$
$$= -4.5579$$

$$k_2 = f(t_0 + h, \theta_0 + k_1 h)$$
$$= f(0+240, 1200+(-4.5579)240)$$
$$= f(240, 106.09)$$
$$= -2.2067\times10^{-12}\left(106.09^4 - 81\times10^8\right)$$
$$= 0.017595$$

$$\theta_1 = \theta_0 + \left(\frac{1}{2}k_1 + \frac{1}{2}k_2\right)h$$
$$= 1200 + \left(\frac{1}{2}(-4.5579) + \frac{1}{2}(0.017595)\right)240$$
$$= 1200 + (-2.2702)240$$
$$= 655.16K$$

Step 2: $i = 1, t_1 = t_0 + h = 0 + 240 = 240, \theta_1 = 655.16K$

$$k_1 = f(t_1, \theta_1)$$
$$= f(240, 655.16)$$
$$= -2.2067\times10^{-12}\left(655.16^4 - 81\times10^8\right)$$
$$= -0.38869$$

$$k_2 = f(t_1 + h, \theta_1 + k_1 h)$$
$$= f(240+240, 655.16+(-0.38869)240)$$
$$= f(480, 561.87)$$
$$= -2.2067\times10^{-12}\left(561.87^4 - 81\times10^8\right)$$
$$= -0.20206$$

$$\theta_2 = \theta_1 + \left(\frac{1}{2}k_1 + \frac{1}{2}k_2\right)h$$
$$= 655.16 + \left(\frac{1}{2}(-0.38869) + \frac{1}{2}(-0.20206)\right)240$$
$$= 655.16 + (-0.29538)240$$
$$= 584.27K$$

b. RK4

Problem:

$$\frac{dy}{dx} = 1 + y + x^2, \qquad y(0) = 0.5$$

Use RK4 to find $y(0.2), y(0.4)$

$h = 0.2$

$f(x,y) = 1 + y + x^2$

$x_0 = 0, \quad y_0 = 0.5$

Fourth Order Runge Kutta (RK4)

$$K_1 = f(x_i, y_i)$$

$$K_2 = f(x_i + \frac{1}{2}h, y_i + \frac{1}{2}K_1 h)$$

$$K_3 = f(x_i + \frac{1}{2}h, y_i + \frac{1}{2}K_2 h)$$

$$K_4 = f(x_i + h, y_i + K_3 h)$$

$$y_{i+1} = y_i + \frac{h}{6}(K_1 + 2K_2 + 2K_3 + K_4)$$

Step1:

$$K_1 = f(x_0, y_0) = 1 + y_0 + x_0^{\,2} = 1.5$$

$$K_2 = f(x_0 + \frac{1}{2}h, y_0 + \frac{1}{2}K_1 h) = 1 + (y_0 + 0.15) + (x_0 + 0.1)^2 = 1.64$$

$$K_3 = f(x_0 + \frac{1}{2}h, y_0 + \frac{1}{2}K_2 h) = 1 + (y_0 + 0.164) + (x_0 + 0.1)^2 = 1.654$$

$$K_4 = f(x_0 + h, y_0 + K_3 h) = 1 + (y_0 + 0.16545) + (x_0 + 0.2)^2 = 1.7908$$

$$y_1 = y_0 + \frac{h}{6}(K_1 + 2K_2 + 2K_3 + K_4) = 0.8293$$

Step 2:

$$K_1 = f(x_1, y_1) = 1.7893$$

$$K_2 = f(x_1 + \frac{1}{2}h, y_1 + \frac{1}{2}K_1 h) = 1.9182$$

$$K_3 = f(x_1 + \frac{1}{2}h, y_1 + \frac{1}{2}K_2 h) = 1.9311$$

$$K_4 = f(x_1 + h, y_1 + K_3 h) = 2.0555$$

$$y_2 = y_1 + \frac{h}{6}(K_1 + 2K_2 + 2K_3 + K_4) = 1.2141$$

i	x_i	y_i
0	0.0	0.5
1	0.2	0.8293
2	0.4	1.2141

c. Euler's Method

$$\frac{dx}{dt} = 37.5 - 3.5x$$

$$f(t, x) = 37.5 - 3.5x$$

The Euler's method reduces to

$$x_{i+1} = x_i + f(t_i, x_i)h$$

For $i = 0,\ t_0 = 0,\ x_0 = 50$

$$x_1 = x_0 + f(t_0, x_0)h$$

$$= 50 + f(0,50)1.5$$

$$= 50 + (37.5 - 3.5(50))1.5$$

$$= 50 + (-137.5)1.5$$

$$= -156.25 \text{g/L}$$

x_1 is the approximate concentration of salt at

$$t = t_1 = t_0 + h = 0 + 1.5 = 1.5 \text{ min}$$

$$x(1.5) \approx x_1 = -156.25 \text{ g/L}$$

For $i = 1$, $t_1 = 1.5$, $x_1 = -156.25$

$$\begin{aligned} x_2 &= x_1 + f(t_1, x_1)h \\ &= -156.25 + f(1.5, -156.25)1.5 \\ &= -156.25 + (37.5 - 3.5(-156.25))1.5 \\ &= -156.25 + (584.38)1.5 \\ &= 720.31 \text{ g/L} \end{aligned}$$

x_2 is the approximate concentration of salt at

$$t = t_2 = t_1 + h = 1.5 + 1.5 = 3 \text{ min}$$

$$x(3) \approx x_2 = 720.31 \text{ g/L}$$

COVENANT UNIVERSITY

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P.M.B 1023, OTA, OGUN STATE, NIGERIA.

TITLE OF EXAMINATION: B.Sc DEGREE EXAMINATION

COLLEGE: SCEINCE AND TECHNOLOGY

SCHOOL: NATURAL AND APPLIED SCIENCES

DEPARTMENT: COMPUTER AND INFORMATION SCIENCES

SESSION: 2015/2016 **SEMESTER: ALPHA**

COURSE CODE: CSC432 **CREDIT UNIT: 2**

COURSE TITLE: FILE PROCESSING **Time: 2 Hours**

INSTRUCTION: ATTEMPT QUESTION ONE (Q1) AND ANY OTHER TWO QUESTIONS

Question 1: (30 Marks)

(A). Encoding transforms data from one representation to another.

(i) Justify this by using Huffman compression algorithm to obtain code words for the statement.

(5 Marks)

(ii). List four advantages and the disadvantages of the code words on the original statement?

(2 Marks)

(b). The compression algorithm that is used for textual data may not go well with image based data.

(i). How can you evaluate different compression algorithms like the Huffman algorithm?**(2 Marks)**

(ii). How can you measure the compression ratio?**(1 Mark)**

(c)In data files, what is the difference between record key and sequential file?(3 Marks)

(d). In files and streams there is read /write functions in standard library. Describe the five (5) functions as follows: (i). fgetc (ii). fputc (iii). (iv). fputs (v). fscanf / fprintf**(5 Marks)**

(e). In a directory, the data structure for OS is to locate files on disk. List and describe the three (3) directory structures.**(3 Marks)**

(f) To create a sequential access file, C imposes no file structure and in fact, no notion of records in a file but programmer is required to provide file structure however, file creation in a sequential access file may be required. Describe the following commands: (a). fprintf (b). feof (c) fclose **(3 Marks)**

(g) Data files can be created, updated and processed by C program. List and describe four (4) data hierarchy in data files processing. **(2 Marks)**

(h). Write a program to display the content of the file that include Student, Name, age, mark and attempt others

(i) Find the sum of mark and average.

(ii) Find the maximum of mark.

(iii) Find the name of student who take the maximum mark.

(iv) Count the number of student who take the mark is 99

(4 Marks)

QUESTION 2:

(A). What is a Stream? List Standard Streams? **(4 Marks)**

(B). Describe standard input stream and give example**(3 Marks)**

(C). List and describe six (6) attributes of files. (6 Marks)

(D). With a typical diagram, discuss the processes involved during disk formatting.**(5 Marks)**

(E). What is the use of followingfunction. (2 Marks)

i. fputs() ii. fgets ( )

QUESTIONS 3:

(A). Sorting only alters the position of an array element and not the value. Justify this statement by discussing how the selection sort differs from insertion sort and write the Java code to showcase the method for implementing the two sorting mechanisms.**(10 Marks)**

(i). Selection sort algorithm**(ii)** The code for selection sort (iii) Insertion sort algorithm

(B). What is defragmentation and in three ways, present and discuss how can the operating system keep track of it? **(5 Marks)**

(C). Discuss different approaches to allocate magnetic disk physical blocks to file logical blocks. Discuss three major methods of allocating disk space. **(5 Marks)**

QUESTION 4.

(A). What happen if the file to be open is alreadyexisting (2 Marks)

(B). Detecting End of File is important. Describe with example how end of file can be detected inC++ **(5 Marks)**

(C). File Modes: Listanddescribewithexample,five (5)differentmode in whichafilecanbeopened. **(8 Marks)**

(D). It is certain that anytime you need to remember something beyond a particular process or computation, it is necessary to think of a file. Therefore, file is a very powerful abstraction. Why?

List five elements of a file that must be considered? **(5 Marks)**

QUESTION 5:

(A). List three methods for accessing file **(3 Marks)**

(B). Describe the three methods for accessing file **(3 Marks)**

(C).Give the meaning for hefollowing

(7 Marks)

fseek.seekg(0,ios::beg):

fseek.seekg(0,ios::cur)

fseek.seekg(0,ios::end)

fseek.seekg(m,ios::beg)

fseek.seekg(m,ios::cur)

fseek.seekg(-m,ios::cur)

fseek.seekg(-m,ios::end)

(Ci) Character by character reading / writing in a file: describe how get() and put() can be used to perform read and write operation on thefile **(3 ½ Marks)**

(D). Describe the built-in function for reading a line of text from afile. (3 ½ Marks)

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MARKING SCHEME

Question 1: (30 Marks)

(A). Encoding transforms data from one representation to another.

(i) Justify this by using Huffman compression algorithm to obtain code words for the statement.

(5 Marks)

(ii). What are the advantages and the disadvantages of the code words on the original statement?

(2 Marks)

Solution

You are allowed to generate a statement of your own using Huffman Compression Algorithm / or using the below

(i)Frequency Table:

Letter	e	n	c	o	d	i	g	s	Sp
Frequency	1	2	1	3	2	2	2	1	2

Priority queue: Priority rule observation

E^1 c^1 s^1 n^2 d^2 I^2 g^2 sp^2 o^3

Tree: As shown in the paper

Codewords:0010 010 0011 111 011 100 010 101 110 100 000 101 111 111 011

(ii)Advantages and disadvantages of the codewords

- it saves memory space to store
- it saves time to serialize to transmitting device when communicated
- saves time when accessing

Disadvantage:

- adds to processing overheads during communication
- may lead to loss of data
- error may be introduced making the document unreliable accessing

(b). The compression algorithm that is used for textual data may not go well with image based data.

(i).How can you evaluate different compression algorithms like the Huffman algorithm?**(2 Marks)**

Solution

Factors for the assessment are:

- relative complexity of the coding algorithm
- memory requirement to implement the algorithm
- speed or time required for the computation
- size of data that can be handled
- how close to decompressed document to the original

(ii). How can you measure the compression ratio?(1 Mark)

Solution

- use of document to compressed ratio
- As a percentage : original size- compressed size/original size * 100

(c)In data files, what is the difference between record key and sequential file?

(2 Marks)

Solution:

Data files

- Record key
  - Identifies a record to facilitate the retrieval of specific records from a file
- Sequential file
  - Records typically sorted by key

(d). In files and streams there is read /write functions in standard library. Describe the five (5) functions as follows: (i). fgetc (ii). Fputc (iii). (iv). fputs (v). fscanf / fprintf(5 Marks)

Solution:

(i) fgetc

- Reads one character from a file
- Takes a **FILE** pointer as an argument
- **fgetc(stdin)** equivalent to **getchar()**

(ii) fputc

- Writes one character to a file
- Takes a **FILE** pointer and a character to write as an argument
- **fputc('a', stdout)** equivalent to **putchar('a')**

(iii) fgets

- Reads a line from a file

(iv) fputs

- Writes a line to a file

(v) fscanf / fprintf

- File processing equivalents of **scanf** and **printf**

(e). In a directory, the data structure for OS is to locate files on disk. List and describe the three (3) directory structures.(3 Marks)

Solution

Single level

- One directory per system, one entry pointing to each file
- Small, single-user or single-use systems
- For example: PDA, cell phone, etc.

Two-level

- Single "master" directory per system
- Each entry points to one single-level directory per user
- Uncommon in modern operating systems

Hierarchical

- Any directory entry may point to
    - Individual file
    - Another directory
- Common in most modern operating systems

(f) To create a sequential access file, C imposes no file structure and in fact, no notion of records in a file but programmer is required to provide file structure however, file creation in a sequential access file may be required. Describe the following commands: (a). fprintf (b). feof (c) fclose (3 Marks)

Solution:

fprintf

- Used to print to a file
- Like printf, except first argument is a **FILE** pointer (pointer to the file you want to print in)

feof(*FILE pointer*)

- Returns true if end-of-file indicator (no more data to process) is set for the specified file

fclose(*FILE pointer*)

- Closes specified file
- Performed automatically when program ends
- Good practice to close files explicitly

(g) Data files can be created, updated and processed by C program. List and describe four (4) data hierarchy in data files processing. (2 Marks)

Solution: Data Hierarchy:

Bit – smallest data item

- Value of **0** or **1**

Byte – 8 bits

- Used to store a character
    - Decimal digits, letters, and special symbols

Field – group of characters conveying meaning

- Example: your name

Record – group of related fields

- Represented by a **struct** or a **class**

Example: In a payroll system, a record for a particular employee that contained his/her identification number, name, address, etc.

(h). Write a program to display the content of the file that include Student, Name, age, mark and attempt others

(i) Find the sum of mark and average.

(ii) Find the maximum of mark.

(iii) Find the name of student who take the maximum mark.

(iv) Count the number of student who take the mark is 99

(5 Marks)

Solution i + ii

```
struct student

{char name[10], int Age, int Mark; };

void main()

{Student S;

Int sum=0, avg, d;

Int max=0;

ifstream X("student.dat");

X.read ((unsigned char*)&S,sizeof(S));

if(X.fail()) break;

Sum = sum + S.Mark;
```

```
if(S.Mark > Max)
Max = S.Mark
d++;
Cout<<“MAX =”<<Max;
}
cout<<“avg = sum/d”<<sum/d<<endl;
X.close();
}
```

Solution (iii)

```
struct student
{char name[10], int Age, int Mark; };
void main()
{student S;
Int max=0 , int d;
ifstream X(“student.dat”);
X.read ((unsigned char*)&S,sizeof(S));
if(X.fail()) break;
if(S.Mark > Max)
Max = S.Mark
S.name = Max;
d++;
Cout<<“NAME =”<<S.name;
}
X.close();
}
```

Solution (iv)

```
struct student
{char name[10], int Age, int Mark; };
void main()
{student S;
int d;
ifstream X("student.dat");
X.read ((unsigned char*)&S,sizeof(S));
if(X.fail()) break;
if(S.Mark == 99)
d++;
Cout<<"NAME ="<<S.name;
}
Cout<<"d="<<d<<endl;
X.close();
}
```

Q2:

(A). What is a Stream? List Standard Streams? (4 Marks)

Solution

A stream is an object where a program can either insert or extract characters to or from it. The standard input and output stream objects of C++ are declared in the header file *iostream*.

There are two streams

1.Standard Input Stream 2.Standard Output Stream

(B). Describe standard input stream and give example(3 Marks)

Ans. Standard Input Stream

Generally, the device used for input is the keyboard. For inputting, the keyword *cin* is used, which is an object. The overloaded operator of extraction, >>, is used on the standard input stream, in this case: *cin* stream. Syntax for using the

standard input stream is cin *followed by the operator* >> *followed by the* variable *that stores the data extracted from the stream.*

For example

int prog; cin >> prog;

In the example above, the variable *prog* is declared as an integer type variable.

The next statement is the *cin* statement. The *cin* statement waits for input from the user's keyboard that is then stored in the integer variable *prog*.

The input stream *cin* wait before proceeding for processing or storing the value. This duration is dependent on the user pressing the RETURN key on the keyboard. Theinput stream *cin* waits for the user to press the RETURN key then begins toprocess the command. It is also possible to request input for more than one variable in a single input stream statement. A single *cin* statement is as follows

cin >> x >> y; is the same as

cin >> x; cin >> y;

In both of the above cases, two values are input by the user, one value for the variable x and another value for the variable y.

(C). List and describe six (6) attributes of files. (6 Marks)

Solution

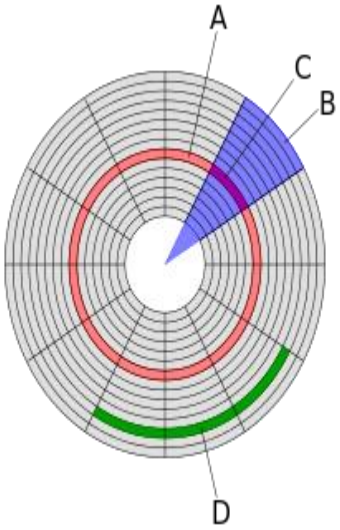
- Name:
  - Although the name is not always what you think it is!
- Type:
  - May be encoded in the name (e.g., .cpp, .txt)
- Dates:

    - Creation, updated, last accessed, etc.
    - (Usually) associated with container
    - Better if associated with content
- Size:
    - Length in number of bytes; occasionally rounded up
- Protection:
    - Owner, group, etc.
    - Authority to read, update, extend, etc.
- Locks:
    - For managing concurrent access

(D). With a typical diagram, discuss the processes involved during disk formatting.

Solution

Processes in disk formatting



i. The vacuum space is divided into memory cells of 8-bit each and addressed in hexadecimal.
ii. The surface is divided into a number of tracks indicated by A
iii. The track is divided into sectors, indicated by C
iv. Group of sectors can form a cluster or block; D
v. Number of cylinders is determined, the blue space labeled B is a cylinder

vi. The operating systems reports the number of tracks, sectors, clusters and cylinder, the good one and bad ones.
(5 Marks)

(E). What is the use of followingfunction. (2 Marks)

ii.fputs ( ) ii. fgets ( )

Solution:

i. fputs ( ) : It writes strings to an opened file.

Syntax:

int fputs (s,Fp)

Sisthestringwewanttowriteintoafilepointedbyfile.pointerFp.

iii.fgets(): Itreadsthecontentsofanopenedfile.
Syntax

char fgets (S, length of a string,Fp)

First argument to this functions is a string, which we want to write in a file.

Second argument is maximum length ofstring.

Thirdargumentisfilepointer,pointingtotheopenedfile.

Decription:

for reading and writing a character from a file there are, fputc ( ) and fgetc( )functions.

Syntax

fputc (ch,fp)

ch is a character we want to store in a file and fp is a pointer, which is openedfile

Syntax

fgetc(fp)

fp is a pointer which points to opened file This function is used for readingthe contents i.e. a character from an openedfile.

QUESTIONS 3:

(A). Sorting only alters the position of an array element and not the value. Justify this statement by discussing how the selection sort differs from insertion sort and write the Java code to showcase the method for implementing the two sorting mechanisms.**(10 Marks)**

Answer:

- 3a.(i)Selection sort algorithm first finds the smallest in the array and exchange it with the element in the first position, then find the second smallest element and exchange it with the element in the second position, and continue in this way until the entire array is sorted.

- 3a (ii) The code for selection sort

```
public void selectionSort() {
        int i, j, min;
        for(i=0; i<n-1; i++) {
                min = i; // minimum
                for(j=i+1; j<n; j++) {
                        if(a[j] < a[min] )
                                min = j;
                                swap(i, min);
                }
        }
}
```

(iii). Insertion sort algorithm iterates through a list of data or elements of an array. It picks the first element, then the second element is compared with this first, if smaller, the second takes the position of the first and the first comes to position two. Picks the third element, insert it in turn to the correct position within a sorted list until the last element is fixed.

The code for Insertion sort:

```
public void insertionSort() {
        int i, j;
        for(i=1; i<n; i++) {
                long temp = a[i];
                j = i;
                while(j>0 && a[j-1] >= temp) {
                        a[j] = a[j-1];
                        --j;
                }
                a[j] = temp;        // insert marked item
        }                           // end for
}                           // end insertionSort
```

(B). What is defragmentation and in three ways, present and discuss how can the operating system keep track of it? (5 Marks)

Solution:

Fragmentation is an operating systems of bringing together unused memory slots so as to provide space for incoming bigger processes.

How it is tracked**:**

a. Using Bit-Vector management approach
   This implements the free spaces as a bit map or bit vector. Depending on the bit setting, each block is represented by a bit. If the block is free, the bit is 0; if the block is allocated, the bit is 1. For example, if a disk has 10 blocks, and blocks 2, 4, 5, and 8 were free, while blocks 0, 1, 3, 6, 7, and 9 were in use, the bit vector would be represented as: 0010110010

b. Linked List approach

- Here, the first free block in memory contains a pointer to the next free block. This next free block contains a pointer to another free block, and so forth, thus forming a linked list. For example, if a disk has 10 blocks, and blocks 2, 4, 5, and 8 were free, while blocks 0, 1, 3, 6, 7, and 9 are used. With this mechanism, the address of block 2 is kept in the directory as the first free block. Attached to block 2 is a pointer pointing to block 3 as the next free block etc

c. Indexed with counting approach

- Rather than keeping a linked list of free disk addresses, an indexed table is created on the first free block. Each entry has the address of the next free block and a constant n of free contiguous blocks that follow the first block. Each entry in the free-space indexed table then consists of a disk address and a count. For example, if a disk has 10 blocks, and blocks 2, 4, 5, and 8 were free, while blocks 0, 1, 3, 6, 7, and 9 are used up

  Indexed table pointer :block 2

Free block	No of spaces
2	1
4	1
5	1
8	1

  i.e. block 4 has space for 1 record

(C). Discuss different approaches to allocate magnetic disk physical blocks to file logical blocks. Discuss three major methods of allocating disk space. (5 Marks)

Solution:

File Allocation techniques **(½ mark for any 3 explained- 1 ½ marks)**

Three major methods of allocating disk space

- Contiguous
- Linked
- Indexed

Contiguous: Arranges space to record sequentially. The next free space is used for the next coming record and thus the records of the file occupy a set of contiguous addresses or physical blocks on the disk. For example, If the file is n logical blocks long, and starts at location b, then it occupies physical blocks b, b+1, b+2, ..., b+n-1

Note that, with this allocation, accessing block b+1 after block b normally requires no head movement

Linked list allocation

Here, each file forms a linked list of physical blocks of its records. What is kept in directory is a pointer to the first and (optionally the last) block of the file. For example, a file of 5 blocks which starts at block 4, might continue at block 7, then block 16, block 10, and finally block 27.

Each block contains a pointer to the next block and the last block contains a NIL pointer.

Indexed allocation

In indexed allocation, each file has its own index block table containing addresses of where records are stored. The i^{th} entry in the indexed table points to the i^{th} sector of the file. To read the ith sector of the file, the pointer in the ith index block entry is read to find the desired sector. Indexed allocation supports direct access, and causes no external fragmentation

QUESTION 4.

(A) . What happen if the file to be open is alreadyexisting (2 Marks)

Solution:

When a file writing only, a new file is created if there no file of that name.If a file of that name exist,, already, then its contents a deleted and the file is presented as a clean file.

(B). Detecting End of File

Describe with example how end of file can be detected inC++ (5 Marks)

Solution

Detectionofendoffileisnecessarytopreventanyattempttoreadthedatafrom the file after all data is read.There are to ways of detecting the end iffile

1. Using object of theifstream
2. Using eof member function from ios class

use of ifstreamobject

An if stream object return a value of 0(zero) if any error in the file operation , or file pointer is actually at the end. Hence while can be used which will terminatewhenfinreturnsavalueofzero(0)onreachingenoffilecondition.

```
while(fin)
        {
                ----------
        }
```

use of eof of file memberfunction

This is another approach to detect end of file. eof is the member function of ios class.It returns a non zero value if eof(end of file condition is encountered)and for normal operation it will returnzero(0).

```
if  (fin.eof()!=0)
      {
                exit(1);
        }
```

(C). File Modes: Listanddescribewithexamplefive (5)differentmodeafilecanbeopened. (8 Marks)

Solution

Thefirstoperationgenerallyperformedonanobjectofoneoftheseclassesisto associate it to a real file. This procedure is known as to *open a file*. An open file isrepresented within a program by a stream object (an instantiation of one of these classes, in the previous example this was myfile) and any input or output operation performedonthisstreamobjectwillbeappliedtothephysicalfileassociatedtoit.

Inordertoopenafilewithastreamobjectweuseitsmemberfunction open().Open method has two arguments , whose syntax is asfollows:

open (filename,mode);

Where

1. filename is a null-terminated character sequence of type const char * (the same type that string literals have) representing the name of the file to be opened, and
2. modeisanoptionalparameterwithacombinationofthefollowingflags:

ios::in	Open for inputoperations.
ios::out	Open for outputoperations.
ios::binary	Open in binarymode.
ios::ate	Set the initial position at the end of the file. If this flag is not set to any value, the initial position is the beginning of thefile.
ios::app	All output operations are performed at the end of the file, appendingthe content to the current content of the file. This flag can only be used in streamsopenforoutput-onlyoperations.
ios::trunc	If the file opened for output operations already existed before, its previouscontentisdeletedandreplacedbythenewone.
ios::nocreate	Open fails if the file does not exisy
ios::noreplace	Open files of the file already exist

Examples

Alltheseflagscanbecombinedusingthebitwiseoperator OR(|).Forexample,ifwewant to open the file example.bin in binary mode to add data we could do it by the followingcalltomemberfunctionopen():

```
ofstreammyfile;
myfile.open ("example.bin", ios::out | ios::app |ios::binary);
```

Each one of the open() member functions of the classes ofstream, ifstream and fstream has a default mode that is used if the file is opened without a second argument:

class	default modeparameter
ofstream	ios::out
ifstream	ios::in
fstream	ios::in |ios::out

To check if a file stream was successful opening a file, you can do it by calling to member is_open() with no arguments. This member function returns a bool value of true in the case that indeed the stream object is associated with an open file, or false otherwise:

```
if (myfile.is_open()) { /* ok, proceed with output */ }
```

(D). It is certain that anytime you need to remember something beyond a particular process or computation, it is necessary to think of a file. Therefore, file is a very powerful abstraction. Why?

List five elements of a file that must be considered? (5 Marks)

Solution:

- Documents, or code
- Databases
  - Very large, possibly spanning multiple disks

- `Streams
  - Input, output, keyboard, display
  - Pipes, network connections, ...
- Virtual memory backing store
- Temporary repositories of OS information

QUESTION 5:

(A). List three methods for accessing file (3 Marks)

Solution

The method for accessing files are as follows:

- Sequential access
- Random access
- Keyed (or indexed) access

(B). Describe the three methods for accessing file (3 Marks)

Solution:

Sequential access:

First, you must "Read" all bytes or records *in order* from the beginning

Sequential access method can write and implicitly truncates

Sequential access method cannot jump around

- Could possibly rewind or back up

Sequential access method is appropriate for certain media or systems

- Magnetic tape or punched cards
- Video tape (VHS, etc.)
- Unix-Linux-Windows *pipes*
- Network streams

Random access method:

The following applies:

- Bytes/records can be read in any order
  - And writing can do the as in to:
    - Replace the existing bytes or records
    - Append to end of file and of course,
    - Cannot insert data between existing bytes!
- Seek operation moves current file pointer
    - Maintained as part of "open" file information
    - Discarded on close

- Typical of most modern information storage
    - Data base systems
    - Randomly accessible multi-media (CD, DVD, etc)

Keyed (or indexed) access method

The following applies:

- Access items in file based on the contents of (part of) an item in the file
- Provided in older commercial operating systems (IBM ISAM)
- Usually handled separately by modern database systems

In file processing, organization and management, directories are fundamental mechanism for interpreting file names in an operating system. List three areas where directories are widely used?

Solution

- system,
- applications, and
- users

(C).Give the meaning for thefollowing (7 Marks)

Solution.

fseek.seekg(0,ios::beg):go to start

fseek.seekg(0,ios::cur) stay at the current position

fseek.seekg(0,ios::end) go to end of file

fseek.seekg(m,ios::beg) move to (m+1)th byte in thefile

fseek.seekg(m,ios::cur) go forward by m byte from current position

fseek.seekg(-m,ios::cur) go backward by m byte from currentpositionfseek.seekg(-m,ios::end) go backward by m byte from end

(Ci)

Character by character reading / writing in a file: describe how get() and put() can be used to perform read and write operation on thefile (3 ½ Marks)

Solution:

The get() and put() function are used handle single character in a file at a time. The function put() writes a single character to the associated stream. Similarly, the functionget()readsasinglecharacterfromtheassociatedstream.

Program to demonstrate is of get and put function

// use of get and putfunction

```
#include <iostream.h>

#include
<fstream.h>
using
namespacest
d;


int  main()

{


charch;


  ofstream outfile("test.txt");


  do{

    ch=cin.get();                    //  get  character
    fromakeyboard.outfile.put  (ch);          // write character to
    file

  }  while (ch!='.');


  return0;

}
```

(D). Describe the built-in function for reading a line of text from afile. (3 ½ Marks)

Solution:

The get and get line functions are used for reading a line of text from a file. The get member function taken three arguments a character array, a size limit and delimiter with default value '\n'. This version reads character andterminates or terminates as soon as the delimiterread.

The getline member function is also used. It inserts a null character after thelineinacharacteraway.Thegetlinefunctionremovesthedelimiterfrom the stream but does not store it in the characterarray.

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P.M.B 1023, OTA, OGUN STATE, NIGERIA.

B.Sc EXAMINATION

COLLEGE: Science & Technology **SCHOOL:** Natural & Applied Sciences
DEPARTMENT: Computer & Information Sciences
SESSION: 2014/2015 **SEMESTER:** Alpha
COURSE CODE: CSC432 **CREDIT UNIT:** 2 **COURSE TITLE:** File Processing
INSTRUCTION: **Attempt Question One and Any other Two (2) Questions**
TIME: 2 HOURS

1) Define the following (i) Index (ii) Clustered Indexes (iii) Heap File (iv) Hash Bashed Indexing **(4 mks)**

2a) Define the following terms **(5 mks)**
I) Internal sort (II) External sorting (III) Insertion sorting (IV) Selection sorting
b) write a short and simple C^{++} linear search function for a key search on this integer array;
{1, 100, 2, 66, 55, 44, 88, 77, 12, 23, 45, 9, 87}. **(5 mks)**

c) Consider an array of numbers "5 1 4 2 8", in a sort.
i.) Sort the array step by step from lowest number to greatest number using bubble sort and In each step, show the elements being compared boldly and uniquely. **(2 ½ mks)**
ii.) Show the number of passes that will be required to finish this sorting? **(2 ½ mks)**
d) State one characteristic each of the five various sort types that you are familiar with. **(5 mks)**

3a) Write a C program to sort (Bubble sort) the given array values into ascending order.
2 6 4 8 101 10 12 89 68 45 37 101 **(6 mks)**

b) Define the following: (a) Record (b) Field (c) Data file **(6 mks)**
c) (i) Explain the concept of file system **(2 mks)**
(ii) Write a C++ program that will ask for a positive number entered from the keyboard and store the value in a transaction file. The program should create another master file and store into the master file, the content of transaction file multiplied by 5.
(6 mks)

4a) Differentiate between Direct access method and Index sequential access method. **(6 mks)**
b) What are master files and transaction files **(6 mks)**
c) Write a C++ program to read the content of a file and write the data into another file created by your program. **(8 mks)**

5) (a) (i) Define file organization **(2 mks)**

(ii) Write a C++ program to demonstrate opening a file in read and write mode. After writing information inputted by the user to a file named afile.dat, the program reads information from the file and outputs it onto the screen **(6 mks)**

b) Write a C++ program to read the content of a file line by line and print out value read if valid if is an integer, otherwise it should printout value read is invalid if not an integer.(**6 mks)**

c) Write short notes on Sequential access method **(6 mks)**

COVENANT UNIVERSITY, OTA
COLLEGE OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF COMPUTER & INFORMATION SCIENCES
Alpha Semester B.Sc (Hons) Examination 2013/2014 Academic Session
CSC432: FILE PROCESSING **2 Units**
INSTRUCTIONS: Attempt Question One and Any other Three (3) Questions (2 Hours)

MARKING SCHEME

e) Define the following (i) Index (ii) Clustered Indexes (iii) Heap File (iv) Hash Bashed Indexing**(4 mks)**
Solution

(i) Index: is a data structure organized based on search key
(ii) Clustered Indexes: is the ordering of data records as that of an index. It reduces the cost of using an index to answer a range of search queries.
(iii) Heap File: is the simplest file structure and is an unordered file. Records are stored in a random order across the pages of a file.
(iv) Hash-based indexes are used for equality selection and cannot support range searches.

2a. Define the following terms **(5 mks)**
II) Internal sort
III) External sorting
IV) Insertion sorting
V) Selection sorting

Solution
2ai) An internal sort is any data sorting process that takes place entirely within the main memory of a computer. This is possible whenever the data to be sorted is small enough to all be held in the main memory.
ii) The External sorting methods are applied only when the number of data elements to be sorted is too large. These methods involve as much external processing as processing in the CPU and it requires auxiliary storage. internal sorting takes small input, whereas external sorting can take larger inputs as much as possible.
iii) Insertion sort: is a simple sorting algorithm that is relatively efficient for small lists and mostly sorted lists, and often is used as part of more sophisticated algorithms. It works by taking elements from the list one by one and inserting them in their correct position into a new sorted list. In arrays, the new list and the remaining elements can share the array's space, but insertion is expensive. Sometimes, they are more efficient for larger lists.
iv) Selection sort: is an in-place comparison sort. It inefficient on large lists, and generally performs worse than the similar insertion sort. Selection sort is noted for its simplicity, and also has performance advantages over more complicated algorithms in certain situations. The algorithm finds the minimum value, swaps it with the value in the first position, and repeats these steps for the remainder of the list. It does no more than *n* swaps, and thus is useful where swapping is very expensive.

b. write a short and simple C++ linear search function for a key search on this integer array;
{1, 100, 2, 66, 55, 44, 88, 77, 12, 23, 45, 9, 87}. (5 mks)

Solution

```
const int arraySize = 100;
int a[arraySize] = {1, 100, 2, 66, 55, 44, 88, 77, 12, 23, 45, 9, 87};
int key = 88;
bool found = false;
for (int i = 0; i < arraySize; i++) {
   if (a[i] == key) {
       cout << "Found it at array subscript " << i << endl;
       found = true;
       break;
   }
}
if (! found)
    cout << "Could not find element " << key << " in array a" << endl;
```

c. Consider an array of numbers "5 1 4 2 8", in a sort.

i) Sort the array step by step from lowest number to greatest number using bubble sort and In each step, show the elements being compared boldly and uniquely. (2 ½ mks)

ii) Show the number of passes that will be required to finish this sorting? (2 ½ ks)

d. State one characteristic each of the five various sort types that you are familiar with. (5 mks)

Solution

- First Pass:
  (5 1 4 2 8) (1 5 4 2 8), Here, algorithm compares the first two elements, and swaps since 5 > 1.
  (1 5 4 2 8) (1 4 5 2 8), Swap since 5 > 4
  (1 4 5 2 8) (1 4 2 5 8), Swap since 5 > 2
  (1 4 2 5 8) (1 4 2 5 8), Now, since these elements are already in order (8 > 5), algorithm does not swap them.
- Second Pass:
  (1 4 2 5 8) (1 4 2 5 8)
  (1 4 2 5 8) (1 2 4 5 8), Swap since 4 > 2
  (1 2 4 5 8) (1 2 4 5 8)
  (1 2 4 5 8) (1 2 4 5 8)
  Now, the array is already sorted, but our algorithm does not know if it is completed. The algorithm needs one whole pass without any swap to know it is sorted.

Third Pass:
(1 2 4 5 8) (1 2 4 5 8)
(1 2 4 5 8) (1 2 4 5 8)
(1 2 4 5 8) (1 2 4 5 8)
(1 2 4 5 8) (1 2 4 5 8)

d.

i. Adaptive Sorts: are sorts that have different operations depending on how pre-sorted the list is (i.e. pre-sorted is faster to sort than not).
ii. Non-Adaptive Sorts: are sorts that have the same sequence of operations independent of the order of the data.
iii. Stable: Stable Sorts preserve the order of duplicate elements e.g. b a(1) a(2) -> a(1) a(2) b)
iv.Non-Stable: Sorts sometimes reverse the order of the duplicates (as in a(2) a(1) b)
v. In-Place: In-Place Sorts uses minimal extra data storage; they sort within the given data structure rather than creating a new one.
vi.Non-In-Place Sorts use extra data storage for more than just swaps, and memory can get out of hand.

3a. Write a C program to sort (Bubble sort) the given array values into ascending order.
2 6 4 8 101 10 12 89 68 45 37 101 (6 mks)

Solution

```
1     3a. /* This program sorts an array's values into ascending order */
2     #include <stdio.h>
3     #define size 10
4
5     /*  function main begins program execution */
6     int main()
7     {
8
9     /* initialize a */
10       int a[size] = { 2, 6, 4, 8, 101, 10, 12, 89, 68,  45, 37, 101};
11       int pass;
12       int i;
13       int hold;
14
15      printf("Data items in original order \n");
16
17    /* output original array */
18       for (i=0; I<size;  i++); {
19          printf("%4d", a[i]);
20       }  /* end for */
21
22
23    /* bubble sort */
```

```
24          /* loop to control number of passes */
25            for (pass=1; pass<size; pass++);  {
26
27          /*loop to control number of comparisons per pass */
28                for (i=0; i<size; i++); {
29          /* compare adjacent elements and swap them if first
30               elements is greater than second elements */
31                if (a[i] >  a[i +1]) {
32                   hold =a[i];
33                   a[i] = a[i +1];
34                   a[i +1] = hold;
35                }  /* end if */
36              }   /* end inner for */
37          } /* end outer for */
38
39
40          printf("\n Data items in ascending order \n");
41
42          /* output  sorted array */
43            for (i=0; i<size; i++);
44               printf("%4d", a[i]);
45          }  /* end for */
46
47          printf("\n");
48          return 0;
49
```

```
Data items in original order
2  6  4  8 101  10  12   89   68   45  37 101
```

3b. Define the following: (a) Record (b) Field (c) Data file (6 mks)

Solution

i. A record is a collection of related data items (possibly of different types) stored in fields and treated as a single entity for processing.

ii. A field is a single data item, and many fields make up a record. Each field has a name and one key field called the primary key is used to identify the record.

iii. A data file is a collection of records holding the same type of information but about different objects or individuals.

(c) (i) Explain the concept of file system (2 mks)

Solution

A file system is the collection of files and directories.

(ii) d) Write a C++ program that will ask for a positive number entered from the keyboard and store the value in a transaction file. The program should create another master file and store into the master file, the content of transaction file multiplied by 5.

(6 mks)

Solution

```
#include <iostream>
#include <fstream>
using namespace std;
int main ()
{
ifstream input_file("data.input"); // open the input file
if (!input_file.is_open()) { // check for successful opening
cout << "Input file could not be opened! Terminating!" << endl;
return 1;
}
ofstream output_file("data.output"); // open the output file
if (!output_file.is_open()) { // check for successful opening
cout << "Output file could not be opened! Terminating!" << endl;
return 1;
}
// read as long as the stream is good - any problem, just quit.
// output is each number times two on a line by itself
int datum;
while (input_file >> datum) {
output_file << datum * 5 << endl;
}
input_file.close();
output_file.close();
cout << "Done!" << endl;
return 0;
}
```

4a. Differentiate between Direct access method and Index sequential access method. (6 mks)

Solution

Records in a direct file are not stored physically one after the other, rather, they are stored on a disk with a particular address or location that can be determined by their key field. The file allows programs to read and write records rapidly in no particular order. The direct access is based on disk model since disk allows random access to any file block,

Whereas

Index sequential file is a compromise between sequential and direct file. It stores records in a file in a sequential order but has an index associated with it. The index lists the key to each group of

records stored and the corresponding disk address for that group. This is similar to the index at the end of a book that gives easy access to the content.

b) What are master files and transaction files (6 mks)

Solution

Master File: This is a permanent file which is kept up to date and stores the main information, summary data and key fields in the data. The master file contains two types of data:

- Permanent data such as personal files, payroll data, employee status (contract, permanent or temporary) and job title.
- Less permanent data such as taxes deducted, hours worked, bonuses received.

Transaction File: This is a temporary file which is used to update the master file after a certain time; usually at the end of the day or at the end of the week. Transaction files perform three important tasks:

- Add a new record to the master file
- Update or change the contents of a record or field.
- Remove records from the master file such as employee dismissal.

All changes in the transaction file are recorded in another file called the transaction log or the change file.

c) Write a C++ program to read the content of a file and write the data into another file created by your program. (8 mks)

Solution

```
// listc.cpp
#include <stdio.h>
main() {
char ch;
FILE * infile;
infile = fopen("B.txt","r");
while (fread(&ch,1,1,infile) != 0)
fwrite(&ch,1,1,stdout);
fclose(infile);
}
```

5) (a) (i) Define file organization (2 mks)

Solution

File organization: is a method of arranging the records in a file when the file is stored on disk.

(iii) Write a C++ program to demonstrate opening a file in read and write mode. After writing information inputted by the user to a file named afile.dat, the program reads information from the file and outputs it onto the screen **(6 mks)**

Solution

```
//opens a file in reading and writing mode.
//After writing information inputted by the user to a file named afile.dat,
//the program reads information from the file and outputs it onto the screen
#include <fstream>
#include <iostream>
using namespace std;

int main ()
{

  char data[100];

  // open a file in write mode.
  ofstream outfile;
  outfile.open("afile.data");

  cout << "Writing to the file" << endl;
  cout << "Enter your name: ";
  cin.getline(data, 100);

  // write inputted data into the file.
  outfile << data << endl;

  cout << "Enter your age: ";
  cin >> data;
  cin.ignore();

  // again write inputted data into the file.
  outfile << data << endl;

  // close the opened file.
  outfile.close();

  // open a file in read mode.
  ifstream infile;
  infile.open("afile.data");

  cout << "Reading from the file" << endl;
  infile >> data;

  // write the data at the screen.
  cout << data << endl;
```

```
    // again read the data from the file and display it.
    infile >> data;
    cout << data << endl;

    // close the opened file.
    infile.close();

    return 0;
}
```

b) Write a C++ program to read the content of a file line by line and print out value read if valid if is an integer, otherwise it should printout value read is invalid if not an integer.

(6 mks)

Solution

```
#include <iostream>
#include <fstream>
using namespace std;
bool get_int(istream&, bool&, int&);
int main ()
{
int datum;
bool value_is_good = false;
ifstream input_file("data1.input"); // open the input file
if (!input_file.is_open()) { // check for successful opening
cout << "File could not be opened! Terminating!" << endl;
return 1;
}
// continue reading integer values as long as get_int returns true
// but don't use the value unless value_is_good is true
while (get_int(input_file, value_is_good, datum))
if (value_is_good)
cout << "value read is " << datum << endl;
input_file.close();
cout << "Done!" << endl;
return 0;
}
bool get_int(istream& in_strm, bool& good_flag, int& x)
{
bool continue_flag;
in_strm >> x;
if (in_strm.good()) {
good_flag = true;
continue_flag = true; // can keep going
}
```

```
else if (in_strm.eof()) {
cout << "End of file encountered." << endl;
good_flag = false;! ! // input value was not obtained
continue_flag = false; // time to stop
}
else if (in_strm.bad()) {
cout << "Hard I/O error" << endl;
good_flag = false;
continue_flag = false; // give up!
}
else if (in_strm.fail()) {
cout << "Invalid input - skipping rest of line" << endl;
in_strm.clear(); // don't forget! Must clear the stream to read it!
char c;
while (in_strm.get(c) && c != '\n'); // may hit eof while skipping
good_flag = false; // value is not good
if (in_strm.good()) // did we hit eof or something else?
continue_flag = true; // no - can keep going
else {
continue_flag = false; // yes - time to stop
cout << "End of file or error while skipping rest of line." <<
endl;
}
}
else {
cout << "Should be impossible to be here!" << endl; // for demo only!
good_flag = false;
continue_flag = false;
}
return continue_flag;
}
```

c. Write short notes on Sequential access method (6 mks)

Solution

A sequential file is one in which the records are stored in sorted order on one or more key fields.

Examples of sequential files

Invoices for customers sorted on customer number

Class registers sorted on last name

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P.M.B 1023, OTA, OGUN STATE, NIGERIA.
B.Sc EXAMINATION

COLLEGE: Science & Technology **SCHOOL:** Natural & Applied Sciences
DEPARTMENT: Computer & Information Sciences
SESSION: 2015/2016 **SEMESTER:** Alpha
COURSE CODE: CSC433 **CREDIT UNIT:** 3
COURSE TITLE: **Computer Graphics and Animation**
INSTRUCTION: **Attempt any 4 questions.** **TIME**: 3 HOURS

1a) In the mechanism of OCR, it is common practice to convert the multilevel image into a bilevel image of black and white.

i) What is this process called? (1mk)
ii) State the OCR stage where it occurs. (1mk)
iii) What are its main advantages? (2mks)

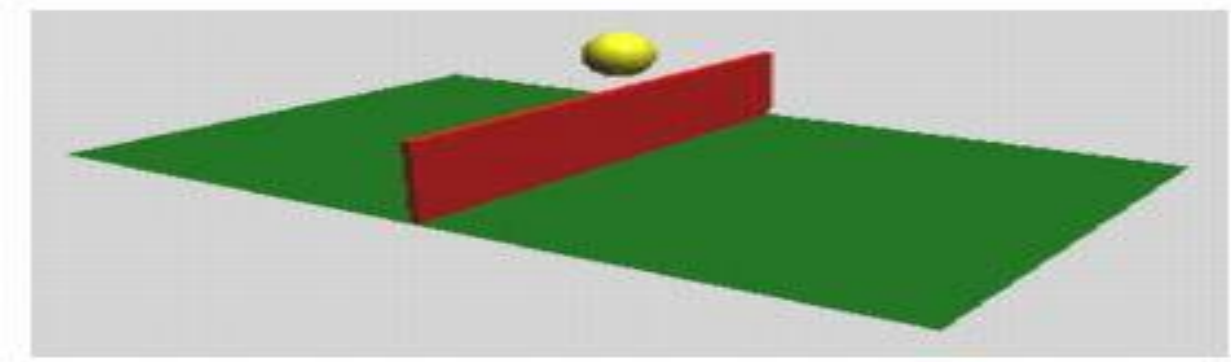


Figure 1

1b) Identify the scene shown as displayed in Figure 1. In tabular form, list the three basic components of the scene and their possible corresponding primitives used in creating each of the models, assuming Maya7 was used. (5marks)

1c) Using Figure 1, outline the steps you will use to colour the largest component of the scene with Green. Note: Steps not listed in the correct sequence will not score. ($8^{1/2}$marks)

2a. Describe the steps and all the events that happen when you animate an object on a motion path. (6mks)

2b i) Draw the diagram of a curve to show the major parts. (2mks)

ii) Discuss each of the elements of a curve. **(5mks)**

2c) What is Anti-aliasing? Describe this concept using a suitable example **(4½mks)**

3a) Comment on the differences iinvolving image file format for PNG and GIF in terms of the following:
i) Compression algorithm used
ii) Average Size Comparison
iii) Patent issues
(6mks)

3b) Every animation scene in Maya require a model to be created or imported, give reasons why you feel that the concept of file image format issues is important in 3D animation. **(4mks)**

3c i) A scene to be modeled and animated will require a **Primitve**, define the term **Primitive** and hence describe 4 common examples of **NURBS primitive** readily available in Maya. **(2½mks)**

ii) We can model the sea floor in Maya. List possible primitives or items in Maya that will aid you to model this scene and briefly explain how this will be accomplished. **(5mks)**

4a. Fundamental to all computer graphics is the ability to simulate the manipulation of object in space. Explain what happen when an object is moved from one spatial plane to another. **(5mks)**

4b. (i) What is object normalization?
(ii) Differentiate between the world coordinate system and a non-device coordinate system **(4½mks)**

4c. There is a need to decide the spatial relationship between an arbitrary line and the clipping window line and to find the intersection point(s). Describe how the Cohen-Sutherland algorithm does this in a 2D graphic plane. **(8mks)**

5a. (i) Comment on the role of point clipping in attaining proper construction of the corresponding image.
(ii) What are the conditions surrounding point clipping?
(9mks)

5b. List four clipping algorithms that can be used in two-dimensional graphic coordinate. **(4mks)**

5c. Find the matrix that represents the rotation of an object in a 2-Dimensional coordinate space by 45° about the origin. What are the new coordinates of the point P(2,-4) after rotation? **(4½mks)**

6a) Segmentation is a stage that helps to determine the constituents of an image and also help to locate the regions of the document. Using this clue, diagrammatically represent and outline four main segmentation challenges that can be feasible or encountered during image segmentation. **(7½mks)**

6b) What is a keyframe and FPS? Mention the fps for Films **(5mks)**

6c) In four steps, outline how you start Maya on Windows 7 and accomplish a task to create a polygonal sphere? Hence, draw a labeled diagram to show the created polygonal sphere:
i) selected for scale operation.
ii) selected for move operation.
(5mks)

MARKING SCHEME

COVENANT UNIVERSITY

DEPARTMENT OF COMPUTER AND INFORMATION SCIENCE

(2015/2016 ALPHA SEMESTER B.Sc (Hons) EXAMINATION)

Course Code: CSC 433 **TIME: 3hrs**

Course Title: Computer Graphics and Animation

Instructions : Attempt 4 questions in all.

1a) In the mechanism of OCR, it is common practice to convert the multilevel image into a bilevel image of black and white.

i) What is this process called? **(1mark)**

ii) State the OCR stage where it occurs**. (1mark)**

iii) What are its main advantages? **(2mark)**

SOLUTIONS

ai) Often this process is known as thresholding. **(1mark)**

ii) Performed on the scanner . **(1mark)**

iii) To save memory space **(1mark)**

and computational effort. **(1mark)**

b.) Identify the scene shown as displayed. In tabular form, list the three components of the scene and the possible corresponding primitives used in creating each of the models, assuming Maya7 was used.

Solution

b) –Moving/Flying ball over a table tennis board net on a table tennis board. **(2mark)**

-

Components	Possible Primitive Used
Board	Plane/Cube
Net	Plane/Cube
Selected Ball for move translation	Sphere

(3x1mks = 3mks)

-No score if not in tabular form

c) Outline the steps you will use to colour the largest component of the scene with green.

Solution

c) STEPS TO COLOUR

- - Start Maya **($^{1/2}$mks)**
- 1. Right-Click the largest board and hold down the mouse to see the Marking menu.
- 2 Click MATERIALS =>
- 3.ASSIGN NEW MATERIALS =>
- 4. Select any colour option eg Blinn => See the COLOUR MATERIAL ATTRIBUTE pane
- 5.Click the colour swatch to see the COLOUR CHOOSER dialogue box
- 6.Click on the colour area you require ie green
- 7.Click ACCEPT button to see the colour on the colour pane
- 8.Press “5” key to shade selected colour automatically/ Click Panel => shade

(1mkx8=8mks)

Subtotal = [17$^{1/2}$mks]

2a. Describe the steps and all the events that happen when you animate an object on a motion path.
[6mks]

To create a motion path by attaching an object to a curve

i. Create a NURBS curve and the ball
-Click Create =>NURBS=> CV tool => Click different spots and double click the final spot to create the curve.
- Click Create =>NURBS=>Sphere to create the ball.

The curve is the path along which the object moves. The direction you create the curve is the direction the object moves**.** **(2mks)**

ii. Select the object you want to animate on the path, and then 

-select the curve.

Note
You can animate many objects along the same path curve by first selecting the objects, and then selecting the curve. You must select the curve to be used as the path curve last.

(1mk)

1. Select Animate > Motion Paths > Attach to Motion Path.

The object moves to the point on the curve where it is positioned for the current time. Also, two motion path markers with numbers appear at each end of the curve. These markers indicate the position and time at which the object moves to those marker positions.

(2mks)

1. To view the animation of the object, click the Play button in the Playback controls.

If your object does not follow the motion path, it may be due to existing transforms on the parent of the object. To move force the object to follow the path, attach the parent of the object o the motion path instead of the object, and then move the parent's pivot until the object (its child) is on the path.

(1mk)

[1mk x6= 6mks]

2b i) Draw the diagram of a curve to show the major parts. ***(2mks)***

ii) Discuss each of the elements of a curve. ***(5mks)***

SOLUTION

i) Appropriate diagram of a curve with correct labels - *(2mks)*

Hull

Curve direction

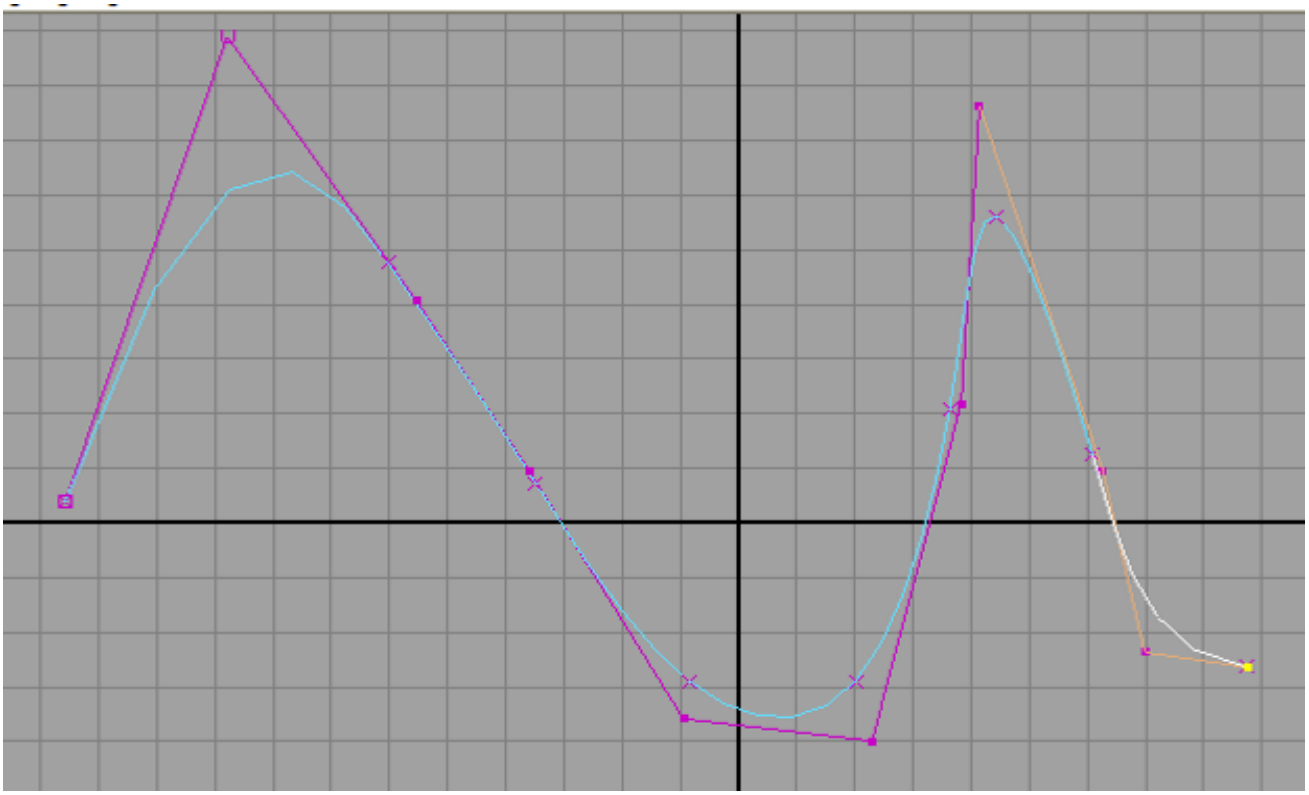
Start of the Curve

Edit point

End of curve

Control

vertex



ii) Hull: Used as visual aids that help you see inter connected CV/Shows interconnected CV and useful to identify which CV will be affected when tweaking a model.

Edit Point: Used to reposition specific points on the curve

CV: Control vertices used to manipulate the shape of a curve

Start of a Curve: This is the first Control Vertex (CV) you create when you draw a

curve/ Indicated by a small hollow box at the first CV.

Curve direction: Indicated by a small U icon on the second CV.

(5x1mk= 5mks)

2c) **What is Anti-aliasing? Describe this concept using a suitable example**

- Anti-aliasing is the application of subtle transitions in the pixels along the edges of images
- to minimize the jagged effect of a raster image enlarged more than 4 times the actual size

($1^{1/2}$mks)

Example: -A raster image of "A" is enlarged more than 4 times its normal size,

- Its edges becomes jagged and it is smoothed by anti-aliasing **(1 mk)**

.

(2mks)

Vector Raster Enlarged

[Subtotal = $17^{1/2}$mks]

==========

3a) Highlight the differences in image file format PNG and GIF in terms of the following:

i) Compression algorithm used
ii) Average file size comparison

iii) Patent issues

(6mks)

-(i)PNG uses ZIP compression which is lossless, while GIF uses LZW (slightly smaller files).

-ii) PNG files are larger than GIF files.

-iii) PNG is a newer format, designed to be both versatile and Patent-free, back when the LZW patent was disputed/PNG provides a patent-free replacement for GIF and can also replace many common uses of TIFF and was developed in 1995/ GIF format is that the LZW algorithm was protected in the USA by a patent held by the company Unisys. The Unisys LZW patent expired in the USA on June 20, 2003.

(2mksx3 = 6mks)

3b) Every animation scene in Maya require a model to be created or imported, give reasons why you feel that the concept of file image format issues is important in 3D animation. (4mks)

-To be able to resolve image compatibility issues among 3D applications.

- To be able to use specific file formats where it will be most suitable eg TIFF for printing, JPG for Photo and GIF for web.

- Other suitable reasons scores (Any 2x2 mks= 4mks)

3c) A scene to be modeled and animated will require a Primitve.

i) Define the term Primitive and otherwise describe 4 common examples of NURBS

primitive readily available in Maya. (5mks)

-Primitives are the simplest forms of 3D objects.

•-They are the basic building blocks used to create more complex models.

(1/2mks)

5 Examples of Primitives include:

• Plane: Flat or level surface

• Cube: Three-dimensional shape with six square or rectangular sides

• Cylinder: Tube, or pole shaped object.

• Cone: Shape whose base is a circle and whose sides taper up to a point

• Sphere: round body whose surface is at all points the same distance from the center

• Torus: donut shaped figure generated by the revolution of a circle or ellipse around a

Point.

(Any 4x1/2=2 mks)

ii) We can model the sea floor in Maya. List possible primitives or items in Maya that

will aid you to model this scene and briefly explain how this will be accomplished.

(5mks)

- NURBS Plane,
- Visor containing Kelp, StarFish, Octopus

(2x1mk= 2mks)

Explanation

- Create a NURBs plane and scale it to size
- Pop some of the surfaces up using move tool
- Open the visor and select the kelp and other sea weeds
- Pop them up to make suitable visor items to grow or sit on the sea floor ie grow them on the surface of the plane.

(Any3 x 1mk = 3mks)

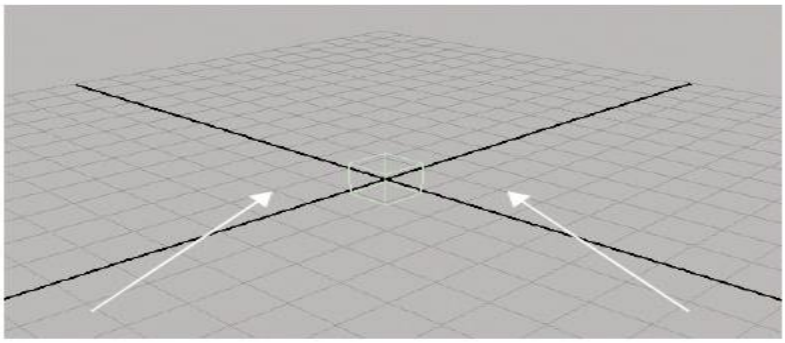
[Subtotal = $17^{1/2}$mks]

4a. Fundamental to all computer graphics is the ability to simulate the manipulation of object in space. Explain what happen when an object is moved from one spatial plane to another.

Answer:

Each object in a space is independently defined with its own coordinate system expressed by (x,y) for two-dimensional space or (x,y,z) for three-dimensional space. Object may be moved relative to a stationary coordinate background (geometric transformation of each point of the object) or may be held stationary while the coordinate system is moved relative to the object (coordinate transformation).

The space occupied by the object is the sum of its coordinate points. E.g. the cube in space



Moving the object to a new position is regarded as creating a new object with all its coordinate points P' obtained relative to the original points P. This displacement in distance and direction (movement) is called translation transformation

(2 marks for explanation of movement translation)

To simulate the movement:

If the displacement is v, then the new object point P'(x',y') is expressed as

P'= T (P), i.e the translation from former position P to P' with the new coordinate x' and y' calculated relative to the original position as:

$x' = x + t_x$

$y' = y + t_y$

t_x is the translation in x coordinate and t_y the translation in y coordinate

(3 marks for explanation of the movement simulation)

4b. (i) What is object normalization? (ii) Differentiate between the world coordinate system and a non-device coordinate system

Answer:

4b (i) Object normalization is the process of converting object coordinates from the world coordinate system (WCS) to a non-device coordinate system (NDCS). The objective is to convert WCS (wx.wy) of an arbitrary point to its NDCS (vx, vy) in order to maintain the same relative placement of the point in the viewport as in the window.

(1mk for definition=1 mark)

4b(ii). The world coordinate system (WCS) (x,y) is a master coordinate plane (window) where a global view of the object to be modeled or transformed is placed. Scene can be created from the object in this window to a normalized device window while a normalized device coordinate system NDCS, is a 1 x 1 square unit that display the area of a virtual display device being used to capture an image. Necessary because of different sizes of capturing device are possible by different graphic applications.

(2 Mk)

Any 2 suitable differences – $1^{1/2}$mks

4c. There is a need to decide the spatial relationship between an arbitrary line and the clipping window line and to find the intersection point(s). Describe how the Cohen-Sutherland algorithm does this in a 2D graphic plane.

Answer

An object in a scene may be completely inside a window, outside the window or partially visible through the window. To eliminate objects or portions of the object that are not visible through the window so as to get a proper construction of the corresponding image, we can use Cohen-Sutherland algorithm. It requires four steps:

1. Assign a 4-bit region code to each endpoint of the line

- Bit representation: bbbb
- 1=endpoint is above, sign($y-y_{max}$)
- 2=endpoint is below, sign($y_{min}-y$)
- 3=endpoint is to the right, sign($x-x_{max}$)
- 4= endpoint is to the left, sign($\mathbf{x}_{min}-x$)

Note that sign(a)=1 if a is +ve, 0 if otherwise

Point with code 0000 is assumed inside the window

2. Test for visibility

- The line is visible if both region codes are 0000
- Not visible if the bitwise logical AND of the codes is not 0000
- It intersects if the bitwise logical AND of the region codes is 0000

3. Chop off or crop the invisible part of a line:

  – Choose an endpoint of the line say (x1,y1) that is outside the window

  – Select an extended boundary line such that its region code can change from a 1 to a 0 i.e.

  – If bit 1 is 1, intersect with line $y=y_{max}$

  – If bit 2 is 1, intersect with line $y=y_{min}$

  – If bit 3 is 1, intersect with line $x=x_{max}$

  – If bit 4 is 1, intersect with line $x=x_{min}$

4. The intersection with clipping window boundary (x_i, y_i) is determined as follow:

If the boundary line is vertical, then

- $x_i = x_{min}$ or x_{max}
- $y_i = y_1 + m(x_i - x_1)$

If the boundary line is horizontal;

- $x_i = x1 + (y_i - y1)/m$
- $y_i = y_{min}$ or y_{max}

where m = (y2-y1)/(x2-x1), the slope of the line

(2 marks (for each step in the algorithm) X 4= 8 marks)

5a. (i) Comment on the role of point clipping in attaining proper construction of the corresponding image.

(ii) What are the conditions and possible effects surrounding line clipping?

Answer:

5(ai) The point clipping operation eliminates objects or portions of the object that are not visible through the normalized device coordinate window so as to get a proper construction of the corresponding image

(2 Mks)

(ii) -Possible if the line from (x1,y1) to (x_2,y_2) satisfies any of the following 4 inequalities:

- $X_1,x_2 > x_{max}$ $y1,y_2 > y_{max}$
- $X_1,x_2 < x_{min}$ $y_1,y_2 < y_{min}$

(1 Mark each for condition x 4= 4 marks)

Effects:

-Visible: both endpoints of the line lie within the clipping window

– Not visible: the line lies outside the window.

- Intersection (clipping candidate) :when the line is neither in category 1 nor 2

(1 Mark (for each category of the point position)x 3= 3 marks)

5b. List four clipping algorithms that can be used in two-dimensional graphic coordinate.

Answer:

Algorithms exist to identify lines that intersect the clipping window and perform the clipping. Among them are:

- Cohen-Sutherland algorithm
- Binary search algorithm
- Liang-Barsky Algorithm
- Sutherland-Hodgman
- Weiler-Atherton
- Warmock's algorithm

(1 marks for any 4= 4 Marks)

5c. Find the matrix that represents the rotation of an object in a 2-Dimensional coordinate space by 45º about the origin. What are the new coordinates of the point P(2,-4) after rotation?

Answer:

$$\mathbf{R_{45}} = \begin{matrix} \cos 45 & -\sin 45 \\ \sin 45 & \cos 45 \end{matrix}$$

$$\mathbf{R_{45}} = \begin{matrix} 1/2 & -1/2 \\ 1/2 & 1/2 \end{matrix}$$

(2 Mark)

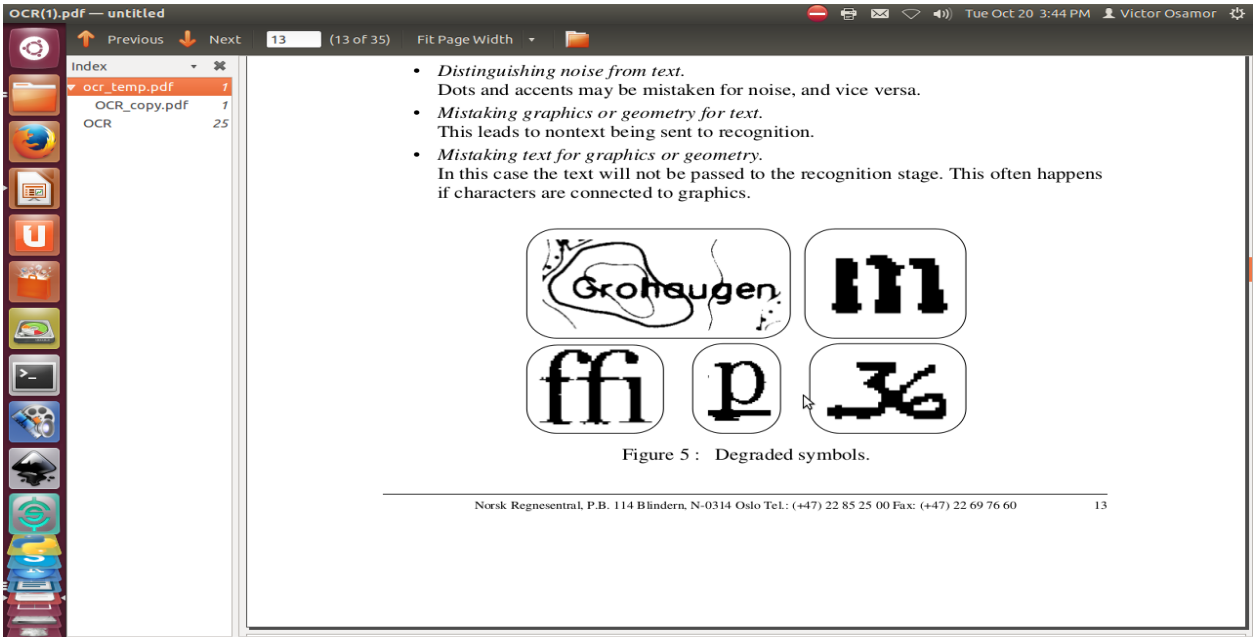
5c ii. the new coordinate of the point(2,-4) is

$$\begin{matrix} 1/2 & -1/2 \\ 1/2 & ½ \end{matrix} \begin{matrix} 2 \\ -4 \end{matrix} = \begin{matrix} 3 \\ 1 \end{matrix}$$

(2 ½Marks)

6a) Segmentation is a stage that helps to determine the constituents of an image and helps to locate the regions of the document. Using this clue, draw and outline four main segmentation challenges that can be feasible or encountered during image segmentation **(8marks).**

Solution



- **Drawings of segmentation challenges** **($2^{1/2}$mks)**
- **Any Suitable correct explanation** **(1mk)**

Outline of Segmentation challenges

j) -Touching and fragmented characters **(1mark)**
k) - Graphics for text mistakes **(1mark)**
l) -Text for Graphics mistakes **(1mark)**
m) - Distinguishing noise from text eg accent symbols **(1mark)**

6b) Keyframe assigns attribute to objects for animation
-Appears as a red line on time slider

-FPS

-fps : means frames per second / frame rate

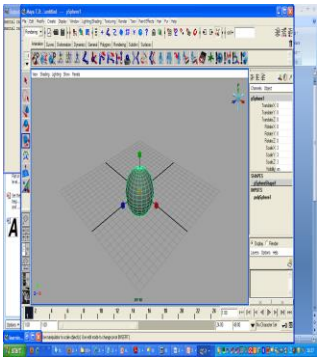
- It is the basic unit of measurement for playing back animation.
- *FPS – Film = 24*

(1mk *x 5mks* = *5mks)*

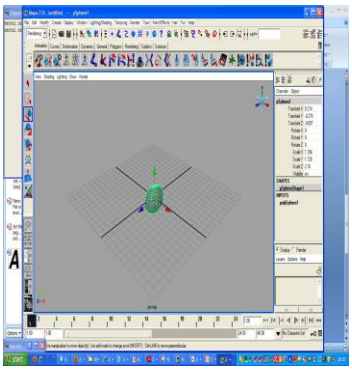
6c) In four steps, outline how you start Maya on Windows 7 and accomplish a task to create a polygonal sphere? Hence, draw a labeled diagram to show the created polygonal sphere:
i) selected for scale operation.
ii) selected for move operation.

1. Click All programs> Alias>Maya to start the program
2. Make sure the menu option is in modeling and click Create
3. Click Polygon
4. Click Sphere

(4x **1/2mks** *= 2mks)*



i) Selected for scaling (**1/2mks** *)*



ii) Selected for moving (**1/2mks** *)*

(1mk eack X2 = 2mks)

GRANDTOTAL = **$17^{1/2}$mks** + **$17^{1/2}$mks + $17^{1/2}$mks+ $17^{1/2}$mks** = 70mks

COVENANT UNIVERSITY

CANAANLAND, KM 10, IDIROKO ROAD
P.M.B 1023, OTA, OGUN STATE, NIGERIA.

TITLE OF EXAMINATION: B.Sc EXAMINATION
COLLEGE: College of Science and Technology
SCHOOL: School of Natural & Applied Sciences
DEPARTMENT: Department of Computer and Information Sciences
SESSION: 2014/2015 **SEMESTER:** ALPHA
COURSE CODE: CSC 433 **CREDIT UNIT:** 3
COURSE TITLE: Computer Graphics and Animation
INSTRUCTION: Answer ANY 4 questions **TIME**: 3 HOURS

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1. (a) Explain the difference(s) between Compter Graphics and Human Computer Interaction. (3 marks)
   (b) Explain the followings:
   i. Digital image ii. Image size iii. Image resolution - 1½mks each (4½ marks)
   (c) Mention at least three (3) different image files representation in computer graphics. (6 marks)
   (d) Mention two common colour models in computer graphics. (4 marks)

2. (a) Briefly explain the following:
   i. Bitmap and pixmap (2 marks)
   ii. Advantages of interactive graphics (4 marks)
   iii. Resolution (4 marks)
   (b) Given two vectors $\underline{a} = [a_x, a_y, a_z]^T$ and $\underline{b} = [b_x, b_y, b_z]^T$. Express the cross product of the two vectors in terms of x, y, and z. (6marks)
   (c) Determine a vector that is orthogonal to the two input vectors in **b** above. ($3^1/_2$ marks)

3. (a) Explain the following 2D transformation in homogenous coordinate:
   i) Rotation ii) shearing and iii) scaling. - 2mks each (6 marks)
   (b) A point p(4,3) is rotated counterclockwise by an angle of 45^o. Find the rotation matrix and the resultant point. (6 marks)
   (c) Distinguish between pixel aspect ratio and aspect ratio. What is the aspect ratio of 12"x16" display. ($5^1/_2$ marks)

4. (a) Explain the basic features of Computer Graphics? (4 marks)
   (b) List the major components (Hardware and Software) needed for computer graphics. (5 marks)
   (c) List and explain at least three important application of computer graphics. (6 marks)

(d) Define computer graphics? ($2^{1}/_{2}$ marks)

5. (a) Is there any difference between computer graphics and image processing? Explain. (5 marks)
   (b) Is it possible to draw a circle using the equation of a circle? Justify your answer. ($6^{1}/_{2}$ marks)
   (c) Consider a raster system with a resolution of 1024 x 1024. What is the size of raster (in bytes) needed to store 4 bits per pixel? How much storage is required if 8 bits per pixel are to be stored? (6 marks)

6. Consider three different raster systems with resolutions of :
   (i) 640x480 (ii) 1280x1024 (iii) 2560x2048
   (a) What size of frame (in bytes) is needed for each of these systems to store 12bits/pixels? (4marks)
   (b) How much storage is required for each system if 24 bits per pixel are to be stored? ($4^{1}/_{2}$marks)
   (c) Given the vectors $\mathbf{M} = \mathbf{i} + 2\mathbf{j}$ and $\mathbf{N} = 2\mathbf{i} - 3\mathbf{j}$, find
      (i) their length (3 marks)
      (ii) their dot product and (3 marks)
      (iii) the angle between them. (3 marks)

Marking scheme-CSC433 (2014_2015 Alpha Semester)

Question One

a. Computer graphics focuses on image production while HCI promotes effective communication between human and machine as depicted in Graphical User Interface (GUI)

b.

i. Digital image is made up of discrete pixels arranged in a row and column format to form a rectangular picture area usually called *raster*

ii. Image size: number of pixels in the horizontal axis times number of pixels in the vertical axis. e.g. 640x480, 800x600, 1024x768

iii. Image resolution: number of pixels per unit length (e.g. inch) in both horizontal and vertical axis

c. Digital images are usually encoded as binary files to aid storage and transmission.

These formats could be

- Bitmaps (BMP)
- Joint Photographic Expert Group file interchange format (JPEG)
- Tagged Image File Format (TIFF)

d. Mention two common colour models in computer graphics
- The most widely used colour representation in computer graphics is the RGB model. R for red, G for green and B for blue
- Mixing these 3 primary colours at different intensity produces variety of colours. (Additive process)
- Another complementary colour model is the CMY model. C for Cyan, M for Magenta, Y for Yellow, the 3 primaries' complementary colours

Question Two

a.

Bitmap and pixmap

A pixmap stores and displays a graphical image as a rectangular array of pixel color values. (The term "pixmap" is short for "pixel map".) A pixmap that uses only a single bit to denote the color of each pixel (resulting in a *monochrome* image) is often referred to as a *bitmap*. Bitmap is also sometimes used to refer to any pixmap.

The term "pixmap" is often used in a general way to describe the actual array of pixels or the image that they create.

A mapping of bits representing the image as an array is known as a bitmap. Similarly, a mapping of pixels is called as a pixmap. From a certain perspective, it can be stated that a mapping with 1- bit per pixel as a bitmap and a mapping with many – bits per pixel as a pix map. In uncompressed formats of bitmaps, image pixels are stored in different color depths within the range from 1, 2, 4, 8, 16, 24, and 32 pixels. Color depths lower than 8-bits are used to store grayscale color or indexed color scales.

Bitmap images are saved with the extension .bmp. Minimum file size of a bitmap image can be obtained by size = width • height • n/8, where height and width are given in pixels, and n is the color depth and size is file size in bytes. With n-bit color depth, a bitmap may incorporate 2n colors in the image.

Advantages of interactive graphics

It producing pictures not only of concrete, real-world objects but also of abstract, synthetic objects, such as mathematical surfaces in 4D and of data that have no inherent geometry, such as survey results.

It has an ability to show moving pictures, and it is possible to produce animations with interactive graphics. With interactive graphics use can also control the animation by adjusting the speed, the portion of the total scene in view, the geometric relationship of the objects in the scene to one another, the amount of detail shown and so on. The interactive graphics provides tool called motion dynamics. With this tool user can move and umble objects with respect to a stationary observer.

Resolution

In computers, **resolution** is the number of pixels (individual points of color) contained on a display monitor, expressed in terms of the number of pixels on the horizontal axis and the number on the vertical axis. The sharpness of the image on a display depends on the **resolution** and the size of the monitor.

b. Given two vectors $\underline{a} = [a_x, a_y, a_z]^T$ and $\underline{b} = [b_x, b_y, b_z]^T$. Express the cross product of the two vectors in terms of x, y, and z.

The cross product of the two vectors in terms of x, y, and z. = $\underline{a} \times \underline{b} = \begin{bmatrix} a_y b_z - a_z b_y \\ a_z b_x - a_x b_z \\ a_x b_y - a_y b_x \end{bmatrix}$

c. Determine a vector that is orthogonal to the two input vectors in **b** above.

The vector that is orthogonal to the two input vectors x and y is:

$$\underline{a} \times \underline{b} = |\underline{a}||\underline{b}| sin\,\theta\,\hat{n}$$

Question Three

(a) Explain the following 2D transformation in homogenous coordinate:
i) Rotation ii) shearing and iii) scaling.

i. A 2-D rotation is done by repositioning the coordinates along a circular path, in the x-y plane by making an angle with the axes. The transformation is given by:

$X_1 = r \cos(\theta + \phi)$ and $Y_1 = r \sin(\theta + \phi)$.

ii. The shearing transformation actually slants the object along the X direction or the Y direction as required. ie; this transformation slants the shape of an object along a required plane.

iii. A 2-D rotation is done by repositioning the coordinates along a circular path, in the x-y plane by making an angle with the axes. The transformation is given by:

$X_1 = r \cos(\theta + \phi)$ and $Y_1 = r \sin(\theta + \phi)$.

(b) A point p(4,3) is rotated counterclockwise by an angle of 45°. Find the rotation matrix and the resultant point.

Rotation Matrix $\underline{\underline{M}} = \begin{bmatrix} cos\theta & -sin\theta \\ sin\theta & cos\theta \end{bmatrix}$

ii. The Resultant Point

$$\underline{\underline{Mp}} = \begin{bmatrix} cos\theta & -sin\theta \\ sin\theta & cos\theta \end{bmatrix} \begin{bmatrix} 4 \\ 3 \end{bmatrix} = \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} \\ 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} \begin{bmatrix} 4 \\ 3 \end{bmatrix} = \begin{bmatrix} 1/\sqrt{2} \\ 7/\sqrt{2} \end{bmatrix}$$

where $\underline{p} = [4\ 3]^T$ and θ = 45°

(c) Distinguish between pixel aspect ratio and aspect ratio. What is the aspect ratio of 12"x16" display.

Pixel aspect **ratio** (often abbreviated PAR) is a mathematical **ratio** that describes how the width of a **pixel** in a digital image compares to the height of that **pixel**. Most digital imaging systems display an image as a grid of tiny, square **pixels**.

The **aspect ratio** is expressed as two numbers separated by a colon (x:y). A common misunderstanding is that x and y represent actual width and height. Actually they represent the relation between width and height. As an example, 8:5, 16:10 and 1.6:1 are the same **aspect ratio**.

What is the aspect ratio of 12"x16" display = 12/16 = ¾

Question Four

(a) Explain the basic features of Computer Graphics

The most important feature of computer graphics is the creation and manipulation of digital images using computer program software.

(b) List the major components (Hardware and Software) needed for computer graphics

Besides the basic computer, some special devices and software may be required especially for computer graphics. For hardware, a special high-resolution, color monitor is often demanded and some input tools, e.g. mouse and joy-sticker, and hard-copy devices, e.g. high-resolution color printer, may be required. For software, some special purpose utilities (device-dependent and (device independence) are needed for handling processing in computer graphics.

Keyboard, Mouse, Trackball, Touchpad, Light Pen, Scanner.

(c) List and explain at least three important application of computer graphics.

Presentation graphics
– Graphics as a support for reports and data presentation
– Most common areas: • Economy • Statistics • Mathematics • Management

Artistic field
– Artistic and commercial objectives
• Logo design • Fine Arts • Animations for advertising

Entertainment: Areas such as • Movies • Television • Computer games etc.

Scientific and medical visualization

– Graphics visualization of huge amount of data

(d) Define computer graphics?

Computer graphics are pictures created using computers and the representation of image data by a computer specifically with help from specialized graphic hardware and software. It is a sub-field of computer science which studies methods for digitally synthesizing and manipulating visual content. Although the term often refers to the study of three-dimensional computer graphics, it also encompasses two-dimensional graphics and image processing.

Question Five

(a) Is there any difference between computer graphics and image processing? Explain.

Computer Graphics is about drawing things on the screen with pixels, using mathematics and physics (trigonometry, lighting, shading, curvature, etc) to give the impression of objects to a human viewer.

The output requirements can be simple eg arcade games, or complex eg realistic rendition for movies.

Image Processing is about taking a digital input (black&white photo or colour photo or scanned image or xerox copy etc) and using mathematics and physics (trigonometry, lighting, shading, curvature, etc) to extract details of objects in that input.

b. Is it possible to draw a circle using the equation of a circle? Justify your answer.

It is possible.

Using Obvious methods

The first obvious method

This is based on cartesian equation of a circle $x^2 + y^2 = R^2$

Where $y = \sqrt{R^2 - x^2}$

This expression is used in the loop below to determine one-quarter of the circle which is then duplicated to complete the circle.

$$for\ x\ =\ 0\ to\ R\ step\ eps\ do$$

$$y = sqrt(R * R - x * x)$$

$$plot(x, y); plot(-x, y)$$

$$plot(x, -y); plot(-x, -y)$$

$$end$$

Second obvious method

This employing parametric equation: $x = Rcos\theta \ \ and \ \ y = Rsin\theta$

This express circle in terms of polar coordinates.

$$for\ \theta = 0\ to \frac{pi}{2}\ step\ \ eps\ \ \ do$$

$$x = R * cos\theta \ \ and \ \ y = R * sin\theta$$

$$plot(x, y); plot(-x, y)$$

$$plot(x, -y); plot(-x, -y)$$

$$end$$

(b) Consider a rater system with a resolution of 1024 x 1024. What is the size of raster (in bytes) needed to store 4 bits per pixel? How much storage is required if 8 bits per pixel are to be stored?

Given resolution = (1024 x 1024)

Case 1: when 1 pixel = 4 bits

Size of raster = 1024 x 1024 x 4 bits

= 1024 x 1024 x4 /8 bytes

= 512 x 1024

= $1 * 2^{19}$ bytes

Case 2: when 1 pixel = 8 bits

Size of raster = 1024 x 1024 x 8 bits

= 1024 x 1024 x8 /8 bytes

= 512 x 1024

= $1 * 2^{20}$ bytes

Question Six

(a) Consider three different raster systems with resolutions of :

(i) 640x480 (ii) 1280x1024 (iii) 2560x2048

(b) What size of frame (in bytes) is needed for each of these systems to store 12bits/pixels?

(c) How much storage is required for each system if 24 bits per pixel are to be stored?

Solution for questions a, b and c

Case 1: when one pixel stores 12 bits, 640 x 480 resolution.

Total # of pixels required = (640 x 480) pixels

Size of frame buffer required = (640*480) pixels
1 pixel can store 12 bits (given)
Size of frame buffer (in bits)
= 640 x 480x 12 bits
= 640 x 480x 12/8 bytes
= 460800 bytes
450KB (1 KB = 1024 bytes)

For 2560 x 2048 resolution:

Size of frame buffer (in bits) = 2560 x 2048 x 12 bits
= 2560 x 2048 x12/8 bytes
= 7.5 MB

For 1280 x 1024 resolution:

Size of frame buffer (in bits) = 1280 x 1024 x 12 bits
= 1280 x 1024 x12/8 bytes
= 1920 KB

Case 2: which one pixel can store 24 bits?

For 640 x 480 resolution: frame buffer size = 1280 x 1024 x24 /8 bytes

= 900KB

For 1280 x 1024 resolution: frame buffer size = 192 x 2KB

= 3840KB

For 2560 x 2048 resolution: frame buffer size = 7.5 x 2 MB

= 15MB

(d) Given the vectors M = **i** + 2**j** and N = 2**i** – 3**j**, find

(i) their length

(ii) their dot product and

(iii) the angle between them.

Given the vectors M = **i** + 2**j** and N = 2**i** – 3**j**

(i) their length $|M| = \sqrt{1^2 + 2^2} = \sqrt{5}$

$$|N| = \sqrt{2^2 + 3^2} = \sqrt{13}$$

(ii) their dot product

$\underline{M} \cdot \underline{N} = M_1N_1 + M_2N_2$

= 1*2 + 2*(-3)

= 2-6

= -4

(iii) angle between them.

$\underline{M} \cdot \underline{N} = |\underline{M}||\underline{N}|cos\theta$

$$cos\theta = \frac{\underline{M} \cdot \underline{N}}{|\underline{M}||\underline{N}|} = \frac{-4}{\sqrt{5 * \sqrt{13}}} = \frac{-4}{65}$$

$$\theta = cos^{-1}\left(\frac{-4}{65}\right)$$

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CANAANLAND, KM 10, IDIROKO ROAD

P.M.B 1023, OTA, OGUN STATE, NIGERIA.

TITLE OF EXAMINATION: B.SC DEGREE EXAMINATION

COLLEGE: SCIENCE AND TECHNOLOGY

DEPARTMENT: COMPUTER AND INFORMATION SCIENCES

SESSION: 2015/2016 **SEMESTER:** ALPHA

COURSE CODE: MIS 412 **CREDIT UNIT:** 2

COURSE TITLE: KNOWLEDGE MANAGEMENT

INSTRUCTION: ANSWER **QUESTION ONE (1)** AND ANY OTHER **TWO (2)** QUESTIONS

TIME: 2 HOURS

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1. (ai) Explain knowledge codification and its attendant benefits to an organization. *(5 marks)*
   (b) Discuss any five (5) techniques for knowledge management codification. *(7½ marks)*
   (c)Discuss **Quality** from the following perspectives: expert's perspective, user's perspective and knowledge developer's perspective. *(3 marks)*
   (d) Identify and discuss the strategies for knowledge transfer. *(3 marks)*
   (e) The process of converting data/information to knowledge occurs in four modes. Describe the four modes *(4 marks)* while also identifying the typologies of KM technologies appropriate for each mode. *(4 marks)*
   (f) Discuss the types of organizational learning. *(3½ marks)*

2. (a) Discuss the role of strategic planning in knowledge management. *(4 marks)*
   (b) Compare and Contrast the conventional SDLC and KMSLC. *(6 marks)*
   (c) With the aid of a suitable diagram, explain the categorizations of groupware. *(5 marks)*
   (d) Identify and explain the challenges in building knowledge management systems. *(5 marks)*

3. (a) What do you understand by knowledge market? Hence describe briefly five types of knowledge market you know. *(8 marks)*
   (b) Discuss briefly any four benefits of knowledge market to an organization. *(5 marks)*
   (c) Explain factors that influence organisations in knowledge market. *(7 marks)*

4. (a) In eliciting expert tacit knowledge, describe the challenges associated with the process. *(4 marks)*
   (b) Discuss any six techniques for capturing expert knowledge to build knowledge management based system. *(12 marks)*
   (c) Identify and explain the levels in the learning organization. *(4 marks)*

5. (a) Differentiate between a learning organization and organizational learning. *(4 marks)*
   (b) Explain briefly the categorization of knowledge. *(6 marks)*

   (c) Discuss the pros and cons of the following expert approaches during knowledge capture: (i) Single expert

   (ii) Multiple expert

   (10 marks)

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TIME: 2 HOURS

Marking Scheme

1. (a) Knowledge codification involves Converting "tacit knowledge" into "explicit usable form". Converting "undocumented" information into "documented" information. Representing and organizing knowledge before it is accessed. It is making institutional knowledge visible, accessible, and usable for decision making
   Benefits of Knowledge Codification are:
   - Instruction/training—promoting training of junior personnel based on captured knowledge of senior employees
   - Prediction—inferring the likely outcome of a given situation and flashing a proper warning or suggestion for corrective action
   - Diagnosis—addressing identifiable symptoms of specific causal factors
   - Planning/scheduling—mapping out an entire course of action before any steps are taken

   (b) The techniques for knowledge codification include:

   Knowledge Maps
   - Knowledge map is a visual representation of knowledge.

- They can represent explicit/tacit, formal/informal, documented/undocumented, internal/external knowledge.
- It is a sort of directory that points towards people, documents, and repositories.
- It may identify strengths to exploit and missing knowledge gaps to fill.
- Knowledge Mapping is very useful when it is required to visualize and explore complex systems.

Decision Table

- It is another technique used for knowledge codification.
- It consists of some conditions, rules, and actions.

Decision Tree

- It is also a knowledge codification technique.
- A decision tree is usually a hierarchically arranged semantic network.

Frames

- A frame is a codification scheme used for organizing knowledge through previous experience. Frames typically describe a collection of attributes that a given object normally possesses.
- The knowledge in a frame is partitioned into slots. A slot can describe declarative knowledge (such as the color of a car) or procedural knowledge.
- Key elements of frames:
    - Slot: A slot is a set of attributes that describe the object represented by the frame.
    - Facet: The value of an object/slot.
- For example, if a chair frame is supposed to have four legs, and a particular chair has only three, then that chair may need to be repaired (Rich, 1983)

Production Rules

- They are conditional statements specifying an action to be taken in case a certain condition is true.
- They codify knowledge in the form of premise-action pairs.
- Syntax: IF (premise) THEN (action)
- Example: IF income is `standard' and payment history is `good', THEN `approve home loan'.

Case-Based Reasoning

- It is reasoning from relevant past cases in a way similar to human's use of past experiences to arrive at conclusions.
- Case-based reasoning is a technique that records and documents cases and then searches the appropriate cases to determine their usefulness in solving new cases presented to the expert.
- The aim is to bring up the most similar historical case that matches the present case.
- Adding new cases and reclassifying the case library usually expands knowledge.
- A case library may require considerable database storage as well as an efficient retrieval system.

Scripts

- A script is a knowledge representation scheme describing a sequence of

events. Some elements of a typical script include entry conditions, props, roles, tracks, and scenes.

- The entry conditions describe situations that must be satisfied before events in the script can occur or be valid.
- Props are objects used in the sequence of events that occur.
- Roles are the people involved in the scripts. The result is condition that exist after the events in the script have occurred.
- Track refers to variations that might occur in a particular script.
- Finally, scenes describe the actual sequence of events that occur.
- Cases and scripts are specialized types of frames that represent typical scenarios or common sequences of event.
- A restaurant script could include a series of events such as entering the restaurant, being seated, ordering food, eating the food, paying the bill, and exiting the restaurant.

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Knowledge-Based Agents

- An intelligent agent is a program code which is capable of performing autonomous action in a timely fashion.
- They can exhibit goal directed behaviour by taking initiative.
- They can be programmed to interact with other agents or humans by using some agent communication language.
- In terms of knowledge-based systems, an agent can be programmed to learn from the user behaviour and deduce future behaviour for assisting the user.

(c) Quality from the following perspectives

- For expert, quality relates to reasoning process that produces reliable and accurate solutions.
- For user, quality relates to system's ease of use and efficiency.
- For knowledge developer, quality relates to how valid the knowledge sources are and how well they are codified into KB.

(d) The strategies for knowledge transfer are:

- Collective sequential transfer –specialized team performs same function at other sites.
- Explicit Inter-team Transfer – one team shares experience with another working on a similar job at another site.
- Tacit knowledge transfer – unique in complex, non-algorithmic projects, where knowledge is mentally stored

(e) The conversion process can be understood in four modes:

a) **Socialization**: Exchange of tacit knowledge among members to create shared mental models and abilities.

b) **Externalization:** Articulation of tacit knowledge and transformation to models, concepts, analogies, stories and metaphors that can be communicated by language.

c) **Combination**: Reconfiguration of existing explicit knowledge to generate new explicit knowledge.

d) **Internalization:** Personalizing or taking ownership of explicit knowledge by living/becoming it.

	To Tacit	To Explicit
	Socialization	**Externalization**
From Tacit	• Knowledge Maps	• Groupware
	• Knowledge Portals	• Workflow
		• Knowledge-Based Systems
		• Knowledge Portals
	Internalization	**Combination**
From Explicit	• Innovation Support Tools	• Intranet
		• Electronic Document Management
		LI>Business Intelligence
		• Competitive Intelligence
		• Knowledge Portals

(f) **Single loop learning** involves an organization responding to changes in its environment by detecting errors and correcting them, but maintaning its existing organizational norms. This occurs when errors are detected and corrected. Firms continue with their present policies and goals. This is the "Lower-level Learning", "Not-Strategic Learning", "This is "Adaptive Learning".

Double loop learning: This occurs when, in additiion to detection and correction of errors, the organization questions and modifies its existing norms, procedures, policies and objectives. It involves changing the organization's knowledge-base or firm-specific competences or routines. It is called "Higher-Level Learning",

2. (a) The role of strategic planning cannot be undermined. A knowledge developer should be able to foresee what the business is trying to achieve, how it will be done, and how the new system will achieve goals. He or she should study the company's resources and culture in a manner that can align the KMS to effectively use these resources to achieve its benefits. Risky to plunge into a KMS without strategy. The knowledge developer should consider the following:
   - Vision: Foresee what the business is trying to achieve, how it will be done, and how the new system will achieve goals
   - Resources: Check on the affordability of the business to invest in a new KM system
   - Culture: Is the company's political and social environment open and responsive to adopting a new KM system?

   (b) Compare and Contrast the conventional SDLC and KMSLC.

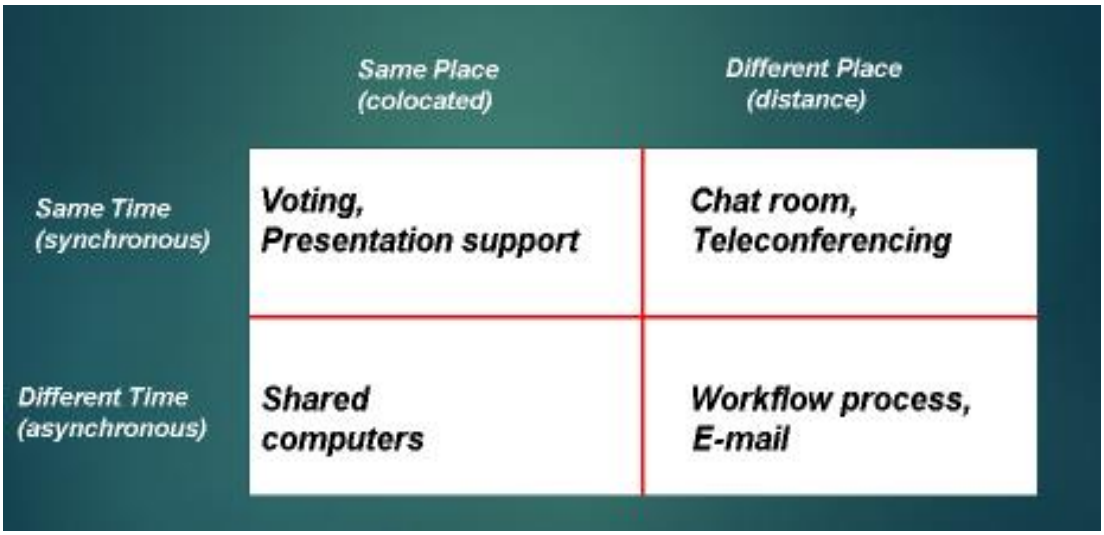
   Key Differences
   - ***Systems analysts*** deal with information from the user; ***knowledge developers*** deal with knowledge from domain experts
   - ***Users*** know the problem but not the solution; ***domain experts*** know both the problem and the solution
   - Conventional SLC is primarily ***sequential***; KM SLC is ***incremental and interactive***.
   - System testing normally at ***end*** of conventional system life cycle; KM system testing ***evolves from beginning*** of the cycle
   - Conventional system life cycle is ***process-driven*** or **"specify then build" while** KM system life cycle is ***result-oriented*** or "**start slow and grow**"

   Key Similarities
   - Both begin with a problem and end with a solution
   - Both begin with information gathering or knowledge capture
   - Testing is essentially the same to make sure "the system is right" and "it is the right system"
   - Both developers must choose the appropriate tool(s) for designing their respective systems

   (c) With the aid of a suitable diagram, explain the categorizations of groupware.

   A groupware is a Software that helps people work together from a distance. It Facilitates knowledge transfer between knowledge seekers and knowledge providers. The categorizations are as follows:

   - Categorized by whether users are working face-to-face (collocated) or in different locations
   - Categorized also by whether users are working together at the same time (synchronous) or different times (asynchronous).



(d) Identify and explain the challenges in building knowledge management systems

- Culture

  – getting people to share knowledge, getting people to the point of willing to share what they know. This challenge is more of an art of doing it, rather than technical. For a knowledge developer, one of the primary skills or qualifications is the ability to get the experts share the tacit knowledge related to the domain of the KMS that is to build.

  If you are in the position of a manager, what are the ways that you can think of to encourage your subordinates to share what they know with one another?

- Knowledge evaluation

  – assessing the worth of knowledge across the organization. This involves the assessment of the worth of knowledge (people, files, documents, databases, etc) that exist across the entire organization, in order to determine both domain and scope of KM projects that should be initiated. This will imply a project in itself, the more substantial the larger an organization. This will imply that one has to selective in determining what are relevant knowledge, where they reside, and what benefits they will derive if they are captured and put in a form that can be shared and used.

- Knowledge processing

  – documenting how decisions are reached. The third challenge is knowledge processing. By knowledge processing, it is the task of finding out how experts make decision on their tasks based on the knowledge they possess. This is an important challenge that will eventually influence the quality of the KM system that is to build.

- Knowledge implementation

  – organizing knowledge and integrating it with the processing strategy for final deployment. This is most technical among the four challenges, and are related to the activity of organizing knowledge that has been identified and integrating it to the processing strategy being adopted by the organization. Being able to successfully overcome this challenge is like overcoming the last hurdle before final deployment of the KM system.

3. (a) **Knowledge Market**

Knowledge Market enables, supports, and facilitates the mobilization, sharing, or exchange of information and knowledge among individuals or groups who has it and those who needs it.

Types of Knowledge Market

- By type of product and service e.g. publications, consultancy, intellectual property rights
- By the type of package e.g. a consultancy project vs. a short piece of advice that answers a specific question
- By the kind of market and communications mechanism e.g. an answer network, phone or email, project matching
- By the scope and coverage e.g. a local area (for certain professional services) vs. international, a specialist niche vs. a broad set of categories publications, consultancy
- How open it is e.g. on the Internet accessible to all, a closed marketplace, internal to a company (on an intranet), open to selected customers (on an extranet).

(b) **Opportunities and Benefits**

- **Better market access.** Suppliers can reach a wider range of potential buyers than normal.
- **Precision matching.** A good product and service classification coupled with good descriptors for suppliers capabilities means that bids and offers can be more closely matched.
- **More transparency.** Open markets allow buyers and sellers to see what is on offer, and what the prevailing market price is.
- **Knowledge co-creation and development.** Markets bring together people sharing similar challenges.

(c)

The factors that organizations should look for in a knowledge market

- **Well publicized and easy to find.** The more buyers and sellers that are attracted to a market, the better it is for everybody.
- **Critical mass.** There should be a sufficient number of buyers and sellers for the particular product or service sought or offered.
- **Well-presented selling space.** Products and services should be easy to locate, and sellers should have opportunities to embellish their descriptions with images and links to more detailed information.
- **Validation of supplier and product.** The more complex the offering, the more that buyers need to understand precisely what it is they are buying. Offering samples and giving buyers the ability to contact previous purchasers will help reduce uncertainty.
- **A fair and transparent pricing mechanism.** Buyers should understand clearly the trading terms and conditions and what is included or excluded in the price. Sellers also need to understand exactly the levels of service the market owner provides, how they will be paid, and precisely what charges will be levied.
- **Incentives.** There must be sufficient incentive for buyers and sellers to want to participate.
- **Sense of community.** The markets that are likely to flourish will be those that go beyond merely offering transaction space. They are likely to act like a portal for particular groups of people, offering news, discussion groups and other facilities that will help knowledge workers in their daily activities.

4. (a) Bottlenecks Associated with Eliciting Experts Knowledge
    - What the experts assumes to be common sense may not be common sense to others.
    - The knowledge engineering paradox – the more expert an individual, the more compiled the knowledge, and the harder it is to extract or elicit this knowledge.
    - The knowledge engineer may misinterpret what the expert is saying.
    - Human biases in judgment on the part of the expert and knowledge engineer may interfere with the knowledge being acquired for the knowledge base.
    - A single knowledge elicitation session could result in many pages of knowledge elicitation transcripts, resulting in difficulty in organizing the knowledge acquired.

(b) **Some Knowledge Capturing Techniques**

- On-Site Observation (Action Protocol)
- Brainstorming
- Electronic brainstorming
- Protocol Analysis (Think-Aloud method)
- Consensus Decision making
- Nominal Group Technique (NGT)
- Delphi Method
- Blackboarding

On-Site Observation (Action Protocol)

- It is a process which involves observing, recording, and interpreting the expert's problem-solving process while it takes place.
- The knowledge developer does more listening than talking; avoids giving advice and usually does not pass his/her own judgment on what is being observed, even if it seems incorrect; and most of all, does not argue with the expert while the expert is performing the task.
- Compared to the process of interviewing, on-site observation brings the knowledge developer closer to the actual steps, techniques, and procedures used by the expert.
- One disadvantage is that sometimes some experts do not like the idea of being observed. It is expensive and time consuming.
- The reaction of other people (in the observation setting) can also be a problem causing distraction.

Brainstorming

- It is an unstructured approach towards generating ideas about creative solution of a problem which involves multiple experts in a session.
- In this case, questions can be raised for clarification, but no evaluations are done at the spot.
- Similarities (that emerge through opinions) are usually grouped together logically and evaluated by asking some questions like:
    - What benefits to be gained if a particular idea is followed?
    - What specific problems that idea can possibly solve.
    - What new problems can arise through this?

- If the experts are unable to agree on a specific solution, the knowledge developer may call for a vote/consensus.

Electronic Brainstorming

- It is a computer-aided approach for dealing with multiple experts.
- It usually begins with a pre-session plan which identifies objectives and structures the agenda, which is then presented to the experts for approval.
- During the session, each expert sits on a PC and gets themselves engaged in a predefined approach towards resolving an issue, and then generates ideas.
- This allows experts to present their opinions through their PC's without having to wait for their turn. Usually the comments/suggestions are displayed electronically on a large screen without identifying the source.
- This approach protects the introvert experts and prevents tagging comments to individuals. The benefit includes improved communication, effective discussion regarding sensitive issues, and closes the meeting with concise recommendations for necessary action
- This eventually leads to convergence of ideas and helps to set final specifications.
- The result is usually the joint ownership of the solution.

Protocol Analysis (Think-Aloud Method)

- In this case, protocols (scenarios) are collected by asking experts to solve the specific problem and verbalize their decision process by stating directly what they think.
- A protocol is a record or documentation of the expert's step-by-step information –processing and decision-making behaviour.
- Knowledge developers do not interrupt in the session, but listens and records the process. The elicited information is structured later when the knowledge developer analyzes and interprets the protocol into knowledge representation for review by the expert.
- Here the term *scenario* refers to a detailed and somehow complex sequence of events or more precisely, an episode. A scenario can involve individuals and objects.
- A scenario provides a concrete vision of how some specific human activity can be supported by information technology.

Consensus Decision Making

- Consensus decision making usually follows brainstorming. It is effective if and only if each expert has been provided with equal and adequate opportunity to present their views.
- In order to arrive at a consensus, the knowledge developer conducting the exercise tries to rally the experts towards one or two alternatives.
- The knowledge developer follows a procedure designed to ensure fairness and standardization. This method is democratic in nature. This method can be sometimes tedious and can take hours

Nominal Group Technique (NGT)

- This provides an interface between consensus and brainstorming.
- Here the panel of experts becomes a *Nominal Group* whose meetings are structured in order to effectively pool individual judgment.
- *Ideawriting* is a structured group approach used for developing ideas as well as exploring their meaning and the net result is usually a written report.
- NGT is an ideawriting technique

Delphi Method

- It is a survey of experts where a series of questionnaires are used to pool the experts' responses for solving a specific problem.
- Each experts' contributions are shared with the rest of the experts by using the results from each questionnaire to construct the next questionnaire

Blackboarding

- In this case, the experts work together to solve a specific problem using the blackboard as their workspace.
- Each expert gets equal opportunity to contribute to the solution via the blackboard. It is assumed that all participants are experts, but they might have acquired their individual expertise in situations different from those of the other experts in the group.
- The process of blackboarding continues till the solution has been reached.
- This approach is useful in case of situations involving multiple expertise, diverse knowledge representations, or situations involving uncertain knowledge representation.

(c) Identify and explain the levels in the learning organization.

Individual Learning is the foundation for the existence of organization's learning and it should be enhanced to lead to more effective OL.

Group/Team Learning is an inseparable step of OL since teams provide new approaches to the learning process, cause fundamental organizational changes by functioning as a bridge between the individuals and the organization (Marquardt,1996).

Organizational Learning requires the crucial step of the transformation of individual learning into OL.

5. (a) A learning organization:
    - Is an organization skilled at creating, acquiring, and transferring knowledge, and at modyfing its behaviour to reflect new knowledge and insights.
    - It is a firm that purposefully constructs structures and strategies, to enhance and maximizes Orgnizational Learning.
    - The concept of a learning organization has become popular since organizations want to be more adaptable to change.

    While Organizational learning is:

    - The process of improving actions through better knowledge and understanding (Fyol & Lyles, 1985)
    - The way firms build,supplement, and organize knowledge and routines around their and within their cultures and adapt and develop organizational efficiency by improving the use of the broad skills of their workforces. (Dodgson, 1993)
    - Learning occurs in an organization "if through its processing of information, the range of its (organization's) potential behaviors is changed (Huber, 1991)

    (b) Categorization/Types of Knowledge

- *Deep Knowledge*: Knowledge acquired through years of proper experience.

- *Shallow Knowledge*: Minimal understanding of the problem area.
- *Procedural knowledge* describes how a problem is solved. This type of knowledge provides direction on how to do something. Rules, strategies, agendas and procedures, are typical type of procedural knowledge used in expert system.
- *Declarative knowledge* describes what is known about a problem. This means a set of principle and facts which can be explained to others..
- *Heuristic knowledge* describes a rule-of-thumb that guides the reasoning process. It is empirical and represents the knowledge compiled by an expert through the experience of solving past problems.
- *Episodic knowledge* represents the knowledge based on episodes (experimental information).
- *Tacit knowledge* usually gets embedded in human mind through experience. Knowledge which draws on accumulated experience and learning of a person and which is hard to reproduce or share with other is called tacit knowledge.

- *Explicit knowledge* is that which is codified and digitized in documents, books, reports, spreadsheets, memos etc.

(c) Discuss the pros and cons of the following expert approaches during knowledge capture:

- Single expert

  Advantages

  - Ideal when building a simple KM system
  - A problem in a restricted domain
  - Easier to coordinate meetings
  - Conflicts are easier to resolve
  - Shares more confidentiality than does multiple experts

  Disadvantages

  - Sometimes expert's knowledge is not easy to capture
  - Single expert provides only a single line of reasoning
  - Expert knowledge is sometimes dispersed
  - Single expert more likely to change scheduled meetings than experts in a team

- Multiple expert

  Advantages:

  - Complex problem domains benefit from expertise of more than one expert
  - Working with multiple experts stimulates interaction
  - Allow alternative ways of representing knowledge
  - Formal meetings often a better environment for generating thoughtful contributions

  Disadvantages:

  - Scheduling difficulties
  - Disagreements often occur among experts
  - Confidentiality issues
  - Requires more than one knowledge developer
  - Overlapping mental processes can lead to "process loss"

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DEPARTMENT: COMPUTER AND INFORMATION SCIENCES

SESSION: 2015/2016 **SEMESTER: ALPHA**

COURSE CODE: MIS415 **CREDIT UNIT: 2**

COURSE TITLE: PROJECT MANAGEMENT **Time: 2 Hours**

INSTRUCTION: ATTEMPT QUESTION ONE (Q1) AND ANY OTHER TWO QUESTIONS

QUESTION 1: (30 Marks)

(a)Discuss the tools and techniques that project managers can use to ensure knowledge and lessons learned from previous projects are not lost, and can be shared for the benefit of future projects.

(4 Marks)

(b).Propose how the effective use of project management software can help an organisation manage its projects throughout each stage i.e. (five stages) of the project life cycle.**(4 Marks)**

(c).Compare and contrast the project evaluation and review technique (PERT) with the critical path method (CPM). **(4 Marks)**

(d). Ability to control the project in a manner that is suitable for the timely execution of the project is a must. However, the project manager is required to collect information to make effective decisions in the steady state phase of a project. Discuss the application to collect information **(2 Marks)**

(e). List and discuss the five (5) basic parameters of the software cost model. **(5 Marks)**

(f) There are old and new ways for improving software economics. With the aid of diagram, by focusing your attention on the old way, list nine (9) conventional software management performances to improve software economics.**[(2 Marks for diagram and nine specifics) (9 Marks)-}(11Marks)]**

QUESTION 2:

(a) There is an accepted deadline for a project approaches. However, the project manager realizes only 75% percent of the work has been completed. The project manager then issues a change request. What should the change request authorized? **(2 ½ Marks)**

(b). Ina difficult project management task, there are situations where lessons learned should be documented. At what point in the project do you need to document lessonslearned? **(2 ½ Marks)**

(c). Using the information in Table 1, assuming that the project team work of a standard working week (5 working days in 1 week) and that all tasks will start as soon as possible:

Table 1: Sample Project Team Work

Project Task	Project Description	Project Duration (Working Days)	Project assigned predecessors
A	Requirement Analysis	5	
B	Systems Designs	15	A
C	Programming	25	B
D	Telecoms	15	B
E	Hardware Installation	30	B
F	Integration	10	C,D
G	System Testing	10	E, F
H	Training and Support	5	G
I	Handover and Go-Live	5	H

(i) Determine the critical path of the project **(2 marks)**
(ii) Calculate the planned duration of the project in weeks **(2marks)**
(iii) Identify any non-critical tasks and the float (free slack) on each. **(1 mark)**

(d). Define the following: (*5* Marks)

(i) Project phase? **(ii)** Milestone?

(iii) Project management methodology? **(iv)**A project?

(v) Characteristics of a project?

(e). Project Management may be like a process for the collection and application of skills and on product development. (*5* Marks)

Answer the following:JUSTIFY

(i) Can the projects critical path change?

(ii) What is project management?

(iii) What is subproject?

(iv) Who is responsible for a project?

(v) What is critical path?

QUESTION 3

(a).A project has a tight budget when you begin negotiating with a seller for a piece of equipment. The seller has told you that the equipment price is fixed. Your manager has told you to negotiate the cost with the seller. What is your BEST course of action? Justify your answer with examples **(2 ½ Marks)**

(b)A project has 13 team members and affects over 15 departments in the organization. Because the project is 20 percent complete to date and the team has had successful performance reports from five of the affected departments, the project manager had a party to celebrate. The project manager was invited to the party and key stakeholders from all of the departments, in order to give those providing good reviews an informal opportunity to communicate good things to those departments that have not yet been affected by the project. At the party, the project manager walked around to try to discover any relevant information that would help the project be more successful. He happened to have heard a manager of a department talking about setting up more regular meetings on the project. Discuss what would be the BEST thing for the project manager to do FIRST. Give examples as related to the question set.**(4 ½ Marks)**

(c).In a project management task, what do we refer to as an Issue?**(2 Marks)**

(d)What is the difference between a risk and anissue?**(3 ½ Marks)**

(e).In software project management what is adeliverable?**(2 Marks)**

(f). What is project agreement and discuss what should contain in project agreement**(5 ½ Marks)**

QUESTION 4

(a).In project management planning, scope, quality or cost are more important. Discuss each as applicable to software project management concept.**(2 Marks)**

(b) Capability Maturity Model (CMM) is a model produced by the Software Engineering Institute to rate an organization's software development process. List and discuss the five (stages/levels applied in CMM model)**(5 Marks)**

(c) What is (EVA) Earned Value Analysis? Define the following basic measure of EVA:

(i) BCW
(ii) BCWS
(iii) BAC
(iv) PV
(v) BCWP
(vi) ACWP

(6 Marks)

(d) There are two major philosophies for creating work breakdown structures. Discuss each and recommend which one is best for managing project as specific to project types**(2 Marks)**

(e) What do you understand by the word "Function Point Analysis". List five (5) possibilities that could be considered for a function point analysis.**(5 Marks)**

QUESTION *5*

(a) Define the following**: (3 Marks)**

- Critical path
- NonCritical Path
- Slack time

(b) There are two (2) ways to analyze dependency diagrams in critical path and as applied to slack time. Discuss! **(2 Marks)**

(c) Do we need to apply the 2 rules of the critical parts and slack times to a project?

You should discuss each of the rules**(4 Marks)**

(d) There are two types of Gannt Chart. Mention and illustrate them with the aid of diagrams.**(6 Marks)**

(e). With aid of diagram discuss the work breakdown structure as applies to project management?

(5 Marks)

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COURSE CODE: MIS415 **CREDIT UNIT: 2**

COURSE TITLE: PROJECT MANAGEMENT **Time: 2 Hours**

INSTRUCTION: ATTEMPT QUESTION ONE (Q1) AND ANY OTHER TWO QUESTIONS

MARKING SCHEME

Question 1: (30 Marks)

(a) Discuss the tools and techniques that project managers can use to ensure knowledge and lessons learned from previous projects are not lost, and can be shared for the benefit of future projects.

(4 Marks)

Students should discuss the tools and techniques that project managers can use to ensure knowledge and lessons learned. Previous experiences on projects are not lost, and can be shared for the benefit of future projects, which provides a broad scope for discussion.

Students should start with a broad overview of everything learned on project management concept and other case study mentioned in the classroom tosee whether there were successes or failures that can serves an important lessons to project manager.

It must be clear that individual project managers usually do learn from their own previous experiences, butthe questions is certain to be informed if all these "lessons learned" are shared with others within the project team or within the same organisation? If they are shared, do other project managers apply the lessons to their own projects? These are key questions which a candidate could summarise.

Student should mention that there are a number of tools and techniqueswhich could be explored, including but not limited to the following:

- Project review procedures

This implies an internal review of project performance, undertaken primarily by the project team as part of the completion phase. The object is to identify strengths and weaknesses in respect of future projects.
Reviews may also be held before the completion of the project, if required.

- Project reports

Frequently, major project teams will be required by the organisation to document the results of the project in a formal project report, thereby making the information available for all those that allow. The quality of such reports can be variable if insufficient time is available.This implies a similar process to an internal review but carried out at least in part by an impartial third party such as consultants. This is not without cost and occasional tension but an independent appraisal may be valuable. An audit conducted before the end of a project is usually a sign of problems being encountered but should still be regarded as a positive process rather than a critical fault-finding exercise.

- Lessons learned database

Many organisations are launching such tools, making lessons learned readily available to staff via electronic means. Frequently, such resources can be found on company intranets. The main challenge is to populate the database with quality information.

- Rotation of project staff or manager

Where feasible, most project organisations regard the rotation of staff as good practice enabling the

sharing of knowledge to be done 'on the job' where strengths from one project can be swiftly applied to another to avoid problems. There are numerous other ways in which a project can be reviewed and candidates should be rewarded for relevant data (e.g. project manager acting as facilitator for best practice etc.)

(b). Propose how the effective use of project management software can help an organisation manage its projects throughout each stage i.e. (five stages) of the project life cycle.(4 Marks)

The question on a proposal in other words can be considered as a detailed point of view of a project. Therefore, studentcould start their proposal with an outline at the most basic level, such like project management software can assist an organisation to manage projects from start to finish, and allow employees at different levels to have an input into the process.

Students could add that project applications can also carry out scheduling, cost control and budget management, resource allocation, collaboration, communication, quality management and documentation or administration.

The aim with these is to handle all aspects and complexities of larger projects and help keep costs down.

However, the question requires a link to a stage process.
During the **first initiation stage** of a project, software can be used to undertake contingency planning and "what if" analysis, allowing project managers to understand the effects of different scenarios.
The case is clear project management software enables the various scenarios to be calculated relatively quickly and easily than would be the case manually. Information can be extracted to support the preliminary business case and with project identification number.

In the **planning phase**, project management software will also make project planning easier in that it will allow the project manager to define the different activities that need to be performed.

It can help in the production of detailed project planning documentation and has applicable functions
During the **execution phase,** the software could help in a number of ways. Project management software is particularly helpful in handling complex projects. Re-planning can be done quickly, for example, estimates may change during the project but project management software can produce revised schedules very quickly, and the changes can be reflected in the project plan immediately. Any changes to task lists will automatically create new schedules for the project. The software facilitates resource planning which should enable the most effective use of the various resources, ensuring during project execution that there are the correct staff levels, equipment and material at the right time.
During the **project control phase**, budget and control features of project software will assist in

monitoring and control. For example, actual costs can be quickly compared with budget costs, at both the level of individual activity and for a project as a whole. This will encourage constant tracking of progress, since actual times can be captured and then comparisons made against planned progress enabling project managers to investigate any problem areas without delay. The software allows both standard and tailored progress reports to be produced. The quality of the documentation will be high, and reports can be extracted and shared with the project team, and other interested stakeholders.

At the **completion stage** of the project life cycle, the software can be used to produce the completion report, since all information on costs and time will have been captured during the life of the project. The information held in the software can also be easily referenced to ensure all aspects of the work scope have been completed.

It should be noted that candidates may refer to alternative project life cycle model other than the five stages outlined above but responses which are simply descriptive will not address all aspects of the question.

In addition, stronger responses might show extended study in this area by outlining that there are many good project management software applications available, (with Microsoft Project being one of the most popular) mid-range project management packages, and the likes of Primavera being popular at the higher end. Often free and open source project tools are also available to download or use via a web browser. This type of additional input should be rewarded.

(c). Compare and contrast the project evaluation and review technique (PERT) with the critical path method (CPM). (4 Marks)

Solution:

Students are required to compare and contrast, the two in order to examine one thing in relation to another so that points of similarity or difference become evident. The contrast element of the response
should further highlight the key differences.

PERT (Programme or Project Evaluation and Review Technique) and CPM (Critical Path Method) are specialised project management techniques and scheduling tools that allow managers to plan, manage and control complex tasks and projects. They are jointly referred to as network analysis, programming models, and critical path analysis (CPA) techniques, and although they are fundamentally different in their unique characteristics, they are usually used in conjunction with each other.

PERT and CPM are used in various industries to effectively plan, organise and monitor project management related activities. PERT charts are management tools that facilitate effective decision making. They are diagrams that represent the flow of activities through a process, highlight all dependent tasks and events, display the sequence of events from the start of a project to its termination and highlight the critical path of a project.

Activities are represented by boxes, and links between different activities are represented by arrows. A
CPM network diagram is activity-oriented, showing the sequence of activities in terms of cost and time.
PERT and CPM define projects by specifying their component tasks and activities.

A PERT/CPM chart clearly shows relationships and dependencies between different tasks of an activity.
When carrying out the comparison and contrast, candidates need to make it clear that PERT is a
probabilistic tool using three estimates of duration for completion of activities of a project and is basically
a tool for planning and control of time whereas, CPM is a deterministic tool, with only single estimate of
duration. CPM also allows an explicit estimate of costs in addition to time; thereby CPM can control both time and costs. This different ion is vital.
While PERT is more suitable for R&D related projects where the project is performed for the first time
and the estimate of duration are uncertain, CPM is best suited for routine and those projects where time
and cost estimates can be accurately calculated.

PERT and CPM are effective forecasting tools and can predict future elements of a process or project.
They allow managers to probe and analyse all possibilities, pitfalls, ambiguities and uncertainties. They
are used to determine and avoid surprises and minimise wastage. Project managers comprehensively
analyse all factors that affect a project and its successful completion in advance, plotting that data clearly
in the form of a diagram.

Higher scoring answers could also add that PERT considers optimistic, likely and pessimistic time,
thereby adding an element of probability to the final figure one obtains. CPM takes only a single time for
any task. This time typically would be the 'likely' time for the task. PERT estimates may prove to be better for projects with long durations due to its ability to absorb a certain level of flux.

(d). Ability to control the project in a manner that is suitable for the timely execution of the project is a must. However, the project manager is require to collect information to make effective decisions in the steady state phase of a project. Discuss the tools application to collect information (2 Marks)

Solution

- Tools to collect information
  - Meetings
    - Periodic status meetings, milestones, project reviews, code inspections, prototype demonstrations
  - Metrics
    - Lines of code, branching points, modularity
    - Defects, mean time between failures

(e) Improving software economics is important for nation development in skills and talents. What is this? List and discuss the five (5) basic parameters of the software cost model. (5 Marks)

Solution

- **Improving Software Economics. How?**
- Reducing Software Product Size
- Improving Software Processes
- Improving Team Effectiveness
- Improving Automation through Software Environments
- Achieving Required Quality
- Peer Inspections: A Pragmatic View

- **Five basic parameters of the software cost model:**
  1. Reducing the size or complexity of what needs to be developed
  2. Improving the development process
  3. Using more-skilled personnel and better teams (not necessarily the same thing)
  4. Using better environments (tools to automate the process)
  5. Trading off or backing off on quality thresholds

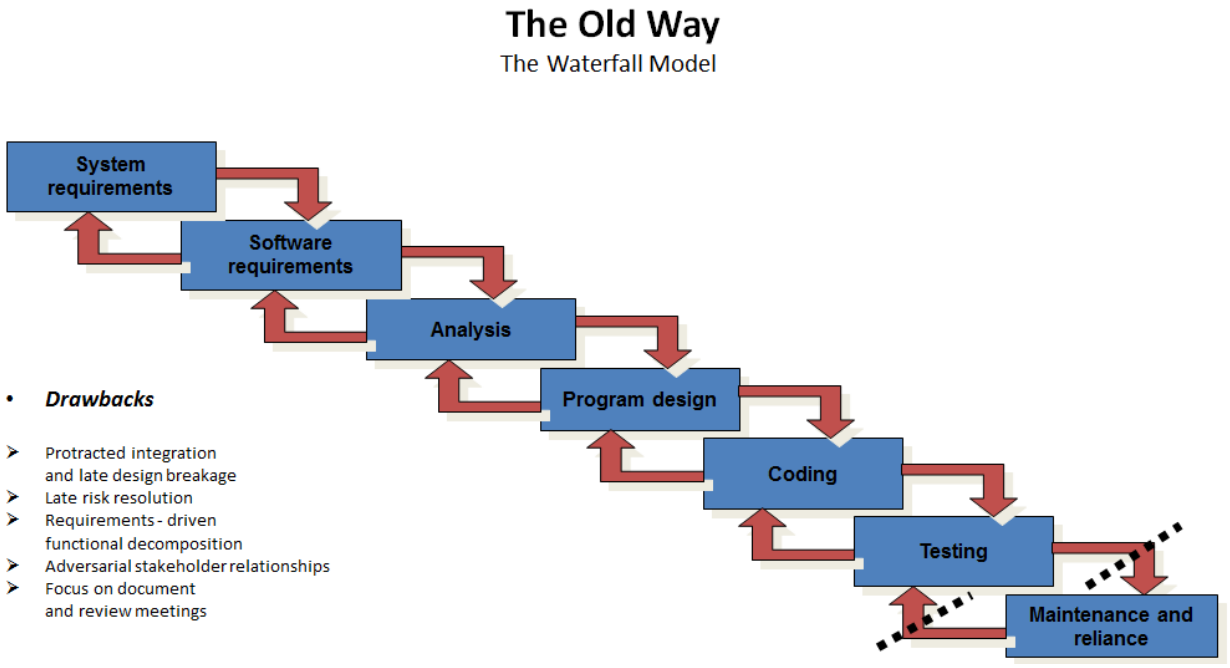
OR

- Most software cost models can be abstracted into a function of five basic parameters:
  - Size (typically, number of source instructions)
  - Process (the ability of the process to avoid non-value-adding activities)
  - Personnel (their experience with the computer science issues and the applications domain issues of the project)
  - Environment (tools and techniques available to support efficient software development and to automate process)
  - Quality (performance, reliability, adaptability...)

(f) There are old and new ways for improving software economics. With the aid of diagram, by focusing your attention on the Old way, list or mention nine (9) nine specific conventional software management performance. [(2 Marks for diagram and nine specifics) (9 Marks)-}(11Marks)]

The Old Way

(Waterfall Model)



Nine Specific Conventional Software Management

1. Finding and fixing a software problem after delivery costs 100 times more than finding and fixing the problem in early design phases.
2. You can compress software development schedules 25% of nominal, but no more.
3. For every #1 you spend on development, you will spend #2 on maintenance.
4. Software development and maintenance costs are primarily a function of the number of source lines of code.
5. Variations among people account for the biggest differences in software productivity.
6. The overall ratio of software to hardware costs is still growing.
7. According to McConnell, Only about 15% of software development effort is devoted to programming.
8. Walkthroughs catch 60% of the errors.
9. 80% of the contribution comes from 20% of contributors.

QUESTION 2:

(a) There is an accepted deadline for a project approaches. However, the project manager realizes only 75% percent of the work has been completed. The project manager then issues a change request. What should the change request authorize? (2 ½ Marks)

Solution

In a project there is always a need for additional resources to be requested. This can be dealt with using the contingency fund approaches. It can be evaluated by the reasons of escalation approval to use contingency funding most importantly when there are staffs who required overtime or team of staff overtime to meet schedule. The project manager must be able to certified the fact that project deadline must meet with the milestone of the budget at any time but in a situation when change request should authorised, there is certainly need for a corrective action based on causes

(b)In a difficult project management task, there are situations where lessons learned should be document. At what point in the project do you need to document lessonslearned? (2 ½ Marks)

Solution

A Lessons Learned document can be created at any point of the project. Typically, Lessons Learned documents are created as a result of a change request, defeat or part of the project closeout process. It is a good idea to create the Lessons Learned document as an ongoing activity, similar to Risk assessment, throughout the project lifecycle to ensure that knowledge is captured, communicated, and integrated into theorganization.

(c)Using the information in Table 1, assuming that the project team will work a standard working week (5 working days in 1 week) and that all tasks will start as soon as possible:

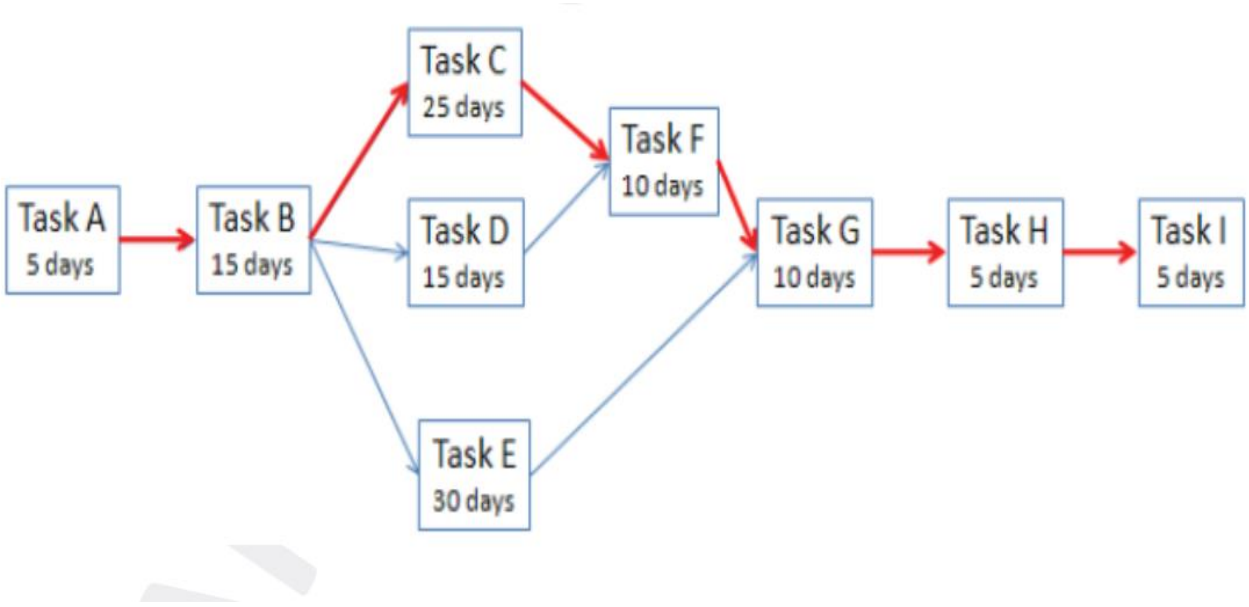
Project Task	Project Description	Project Duration (Working Days)	Project assigned predecessors
A	Requirement Analysis	5	
B	Systems Designs	15	A

C	Programming	25	B
D	Telecoms	15	B
E	Hardware Installation	30	B
F	Integration	10	C,D
G	System Testing	10	E, F
H	Training and Support	5	G
I	Handover and Go-Live	5	H

(i) Determine the critical path of the project **(2 marks)**
(ii) Calculate the planned duration of the project in weeks **(2marks)**
(iii) Identify any non-critical tasks and the float (free slack) on each. **(1 marks)**

Solution

(i). The critical path of the project can be ascertained as follows:



The critical path runs through Tasks A, B, C, F, G, H and I

(ii) The sum of the critical task durations is 75 days - therefore the planned duration of the project is 15
weeks. *If 75 days is stated award*

(iii) Task D is non-critical with 10 days (2 weeks) float
Task E is non-critical with 5 days (1 week) float

(d). Define the following: (5 Marks)

(i) What is a project phase?

(ii) What is a milestone?

(iii) What is a project management methodology?

(iv) what is a project?

(v) what are the chateristics of a project?

Solution

(i)A Project Phase is a logical grouping of related or dependent activities and their related deliverables. Each Project Phase constitutes a very important milestone in aproject.

(ii) A Milestone is a symbol that marks a point in time where something will be produced or when an event will occur during a projectlifecycle.

(iii)A Project Management Methodology is the overall approach (system) that will be followed to meet the project objective(s). Forexample:

- Naming strategy for the ProjectPhase
- Naming and numbering scheme for a Code of Account (Work BreakdownStructure)
- Selection of templates used on aproject
- Selection of deliverables to be produced for a particular type ofproject

(iv) A Project is an initiative launched to create a unique product or service. A Project has a defined start date and a defined end date. The start date represents when the project will be launched. The end date specifies when the project will be completed.A Project is not a reoccurring activity; but rather is a single effort to produce somethingnew.

(v).A Project has threecharacteristics:

- Temporal nature (Is not ongoing and has a definite start and enddate.)
- Unique Deliverable (Produces a new unique product or service that does notexist.)
- Progressive (Actions follow a sequence or pattern and progresses overtime.)

(e). Project Management may be like a process for the collection and application of skills and on product development. Answer the following: (5 Marks)

(i) Can the projects critical path change? (ii) What is project management? (iii) what is subproject

(iv) who is responsible for a project? (v) what is critical path?

Solution

(i) Yes, the critical path is based on the estimated duration of a series of tasks that determine the longest path to complete the project. Therefore, the project's critical path is subject to change if there is a change to the number of tasks, duration, or sequencing ofthose.

(ii) Project Management is the collection and application of skills, knowledge, processes, and activities to meet a specific objective that may take the form of a product or service. Project Management is an integrated process of applying 5 major processes and their related activities throughout a projectlifecycle:

Initiating

Planning

Executing

Monitoring and controlling

Closeout

(iii) A Subproject is a project that has been divided into smaller project to maximize control or contracted to another group for better management. A project can be divided into a number of subprojects each with its own Project Work BreakdownStructure.

(iv) The Project Manager is directly responsible for the results of the project. He/She should use the necessary skills, knowledge, and tools to meet the project objective(s). During the early phases of the project, the Project Manager, working with the project team, should be able to:

- Determine project goalsand objectives
- Determine assumptionsandconstraints
- Define and validateproduct description

- Determine projectrequirements
- Define Projectdeliverables
- Estimate and monitor project resourceallocation

(v) Critical path is the longest path to complete the project that contains no float by aligning all of the project activities to complete the project. The goal of critical path is to determine the blend of activities that determine the project completion date based on the tasks estimated duration. Critical path uses fivevariables:

EarliestStart(ES) EarliestFinish(EF) Late Start(LS)

Late Finish (LF) Duration

QUESTION 3

(a)A project has a tight budget when you begin negotiating with a seller for a piece of equipment. The seller has told you that the equipment price is fixed. Your manager has told you to negotiate the cost with the seller. What is your BEST course of action? **(2 ½ Marks)**

Solution

In a situation like this postponing project negotiations until one can convince manager to change his mind may be considered but from anther perspective holding on to negotiations in other to focus attention on other aspects of the project will not be an ideal option or rather to cancel the negotiations may the worse scenario. **Therefore, a project staff must be able to make a good faith effort to find a way to decrease the cost.**

(b)The project has 13 team members and affects over 15 departments in the organization. Because the project is 20 percent complete to date and the team has had successful performance reports from five of the affected departments, the project manager holds a party to celebrate. The project manager invites to the party key stakeholders from all of the departments, in order to give those providing good reviews an informal opportunity to communicate good things to those departments that have not yet been affected by the project. At the party, the project manager walks around to try to discover any relevant information that would help the project be more successful. He happens to hear a manager of the departments talking about setting up more regular meetings on the project. **Discuss what would be the BEST thing for the project manager to do FIRST. Give example as related to the question set. (4 ½ Marks)**

Solution

Recording the effectiveness of the party involved in the project lessons learned may be justified but it would require taking some of all the stakeholders' time when there is only one stakeholder – the manager – who definitely has an issue. Besides, a good project manager would be holding regular meetings with the stakeholders already. It might be as the manager apparently is not communicating with the project manager. However, this would not absolutely make sure that he is not getting the information he needs but his lack of needed information is causing him to suggest more meetings. Too many meetings are a problem on projects. However, the concept of information distribution is to determine who needs what information and plan how to get it to them. A great project manager does not just add meetings, but solves the real problem in the best way. That might take the form of changing a report or sending existing reports to different people rather than adding meetings. Amongst the aforementioned, reviewing the information distribution method on the project would be the best thing for the project manager to do FIRST. Give example: In a generic way is accepted.

(c)In a project management task, what do we refer to as an Issue? (2 Marks)

Solution: An Issue is an unplanned consideration, concept, or circumstance that arises out of a new discovery or discourse that may impact the project objectives. Issue may arise out of a concern, dispute between project stakeholders, or discussions. Basically, an Issue is an introduction of new information that warrants discussion orconsideration in a project task management

(d) What is the difference between a risk and anissue? (3½ Marks)

Solution: The difference between a Risk and an Issue is that a Risk is 'planned for'. As part of the Risk assessment process, a Risk is identified, qualitatively and quantitatively analyzed, and a response is determined and monitored. An Issue is a new consideration that needs to be analyzed before a determination is rendered. Similar to a Risk, an Issue can potentially be an opportunity (positive impact) or thread (negative impact) on the projectobjectives.

(i). In software project management what is aDeliverable? (2 Marks)

Solution:A Deliverable represents a product that is produced as a result of completing one or more activities. A Deliverable is a verifiable element that can be inspected or qualified to determine that one or more activities were performed to complete a process or project phase. Deliverables and their associated activities and processes are grouped into ProjectPhases.

(e). What is Project Agreement and discuss what should contain in project agreement (5 ½ Marks)

Solution

- Document that formally defines the scope, duration, cost, and deliverables
  - Contract or statement of work, business plan, or charter
  - Typically finalized after the analysis model is stabilized
- Should contain
  - List of deliverables
  - Criteria for demonstrations of functional requirements
  - Criteria for demonstration of nonfunctional requirements
  - Criteria for acceptance
- Represents the baseline of the client acceptance test
- Changes in the functionality, deadlines, or budget requires renegotiation of the project agreement

QUESTION 4

(a). In project management planning, Scope, Quality or Cost are more important. Discuss each as applicable to software project management concept. (2 Marks)

Solution: They are all equally important. Whenever a project activity is performed, the project team should reference the Project Management Plan to ensure that the product or service meets the customer's exception and fulfills a true need—all of which working withinbudget.**Quality** should never be sacrified. Scope is managed by the project **scope** and work breakdown structure. All deliverables produced on the project should be identified in the **Project Work Breakdown Structure**. The project's cost baseline should be managed and reviewed regularly to track performance related information to the deliverables produced at each projectphase.

(b) Capability Maturity Model (CMM) is a model produced by the Software Engineering Institute to rate an organization's software development process. List and discuss the five (stages/levels applies in CMM model) (5 Marks)

Solution

Level 1: Initial - Lowest level, chaotic

Level 2: Repeatable – Project tracking of costs, schedule, and functionality. Able to repeat earlier successes.

Level 3: Defined – A documented and standardized software process. All development accomplished using the standard processes.

Level 4: Managed – Quantitatively manages the process and products.

Level 5: Optimizing – Uses the quantitative information to continuously improve and manage the software process.

(c)What is (EVA) Earned Value Analysis? Define the following basic measure of EVA:

(vii) BCW
(viii) BCWS
(ix) BAC
(x) PV
(xi) BCWP
(xii) ACWP

(6 Marks)

Solution:

EVA is a basic measures to calculate how much has been accomplished

- Percent of the estimated time that has been completed

Basic Measures

- Budgeted Cost of Work (BCW)
  - The estimated effort for each work task
- Budgeted Cost of Work Scheduled (BCWS)
  - The sum of the estimated effort for each work task that was scheduled to be completed by the specified time
- Budget at Completion (BAC)
  - The total of the BCWS and thus the estimate of the total effort of the project

- Basic Measures

- Planned Value (PV)
  - PV = BCW/BAC
  - The percentage of the total estimated effort assigned to a particular work task
- Budgeted Cost of Work Performed (BCWP)
  - The sum of the estimated efforts for the work tasks completed by the specified time
- Actual Cost of Work Performed (ACWP)
  - Sum of the actual efforts for the work tasks that have been computed

(d) There are two major philosophies for creating work breakdown structures. Discuss each and recommend which one is best for managing project as specific to project types**(2 Marks)**

Solution

- Two major philosophies
  - Activity-oriented decomposition ("Functional decomposition")
    - Write the book
    - Get it reviewed
    - Do the suggested changes
    - Get it published
  - Result-oriented ("Object-oriented decomposition")
    - Chapter 1
    - Chapter 2
    - Chapter 3
- Which one is best for managing? Depends on project type:
  - Development of a prototype
  - Development of a product
  - Project team consist of many unexperienced beginners
  - Project team has many experienced developers

(e) What do you understand by the word "Function Point Analysis". List five (5) possibilities that could considered for a function point analysis. (5 Marks)

Solution

- Identify and quantify the functionality required for the project. Individual function points classified as simple, average, or complex, and weights are summed. Correlate total with PM; can capture effort for hidden items (e.g. one output, lots of internal work)
- Some possibilities, but no standards for what is considered a function point:
  - Inputs
    - Logical input, not individual fields
  - Outputs
    - Displays of application data
  - Inquiries
    - Request/response pairs
  - Internal files
    - Number of logical files
  - External interfaces
    - Data shared with other programs

QUESTION *5*

(a) Define the following: (3 Marks)

- Critical path
- NonCritical Path
- Slack time

Solution:

- Critical path:
  - A sequence of activities that take the longest time to complete
  - The length of the critical path(s) defines how long your project will take to complete.
- Noncritical path:
  - A sequence of activities that you can delay and still finish the project in the shortest time possible.
- Slack time:
  - The maximum amount of time that you can delay an activity and still finish your project in the shortest time possible.

(b) There are two (2) ways to Analyze Dependency Diagrams in Critical path and as applied to slack time. Discuss! (2 Marks)

Solution:

- Forward pass: Goal is the determination of critical paths
  - Compute earliest start and finish dates for each activity
  - Start at the beginning of the project and determine how fast you can complete the activites along each path until you reach the final project milestone.
- Backward pass: Goal the determination of slack times
  - Compute latest start and finish dates activity
  - Start at the end of your project, figure out for each activity how late it can be started so that you still finish the project at the earliest possible date.

(c) Do we need to apply the 2 rules of the critical parts and slack times to a project? YES or NO

You should discuss each of the rules (4 Marks)

Solution

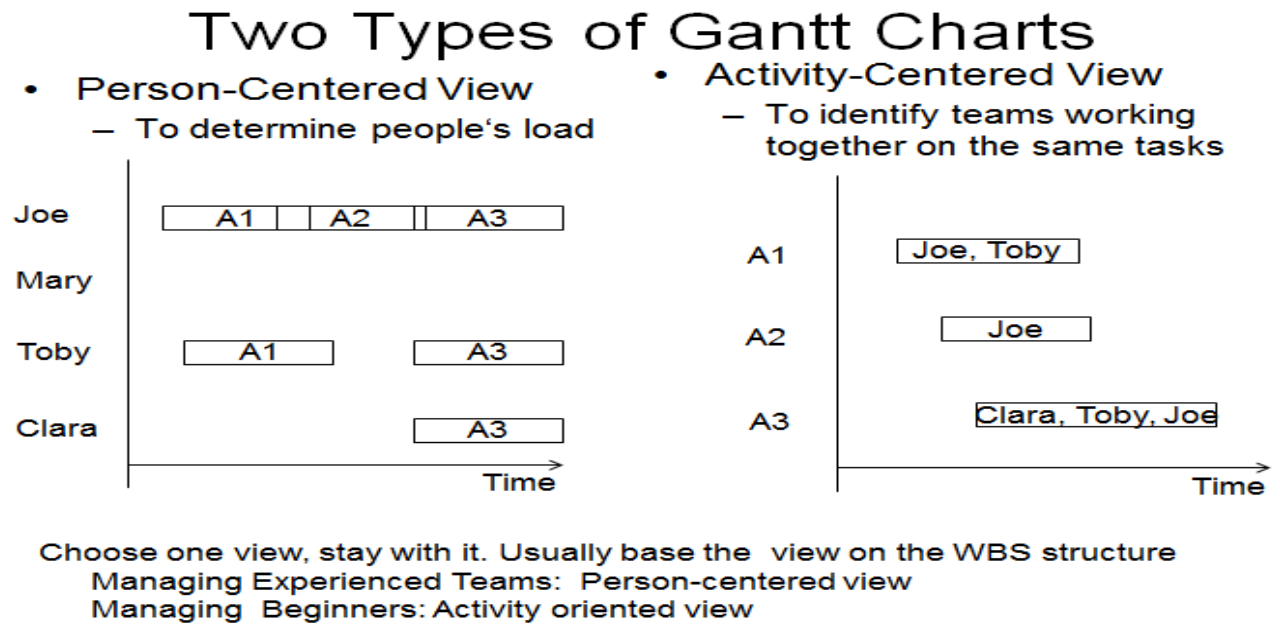
- To compute start and finish times, we apply 2 rules
  - Rule 1: After a node is finished, we can proceed to the next node(s) that is reachable via a transition from the current node.

– Rule 2: To start a node all nodes must be complete from which transitions to that node are possible.

(d)There are two types of Gannt Chart. With the aid of diagram mention the two.

(6 Marks)

Solution



(e). With aid of diagram discuss the work breakdown structure as applies to project management?

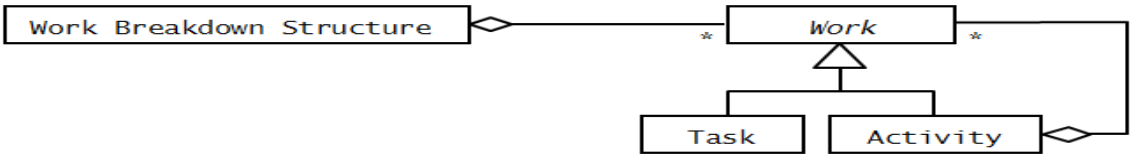
(5 Marks)

Solution

Simple hierarchical model of the work to be performed; uses aggregation only

Work Breakdown Structure

- Simple hierarchical model of the work to be performed; uses aggregation only



COVENANT UNIVERSITY

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P.M.B 1023, OTA, OGUN STATE, NIGERIA.
B.Sc (Hons) Examination

COLLEGE: Science & Technology **SCHOOL:** Natural & Applied Sciences
DEPARTMENT: Computer & Information Sciences
SESSION: 2014/2015 **SEMESTER:** Alpha
COURSE CODE/TITLE: MIS415/ Project Management **CREDIT UNIT:** 2
INSTRUCTION: Answer any three questions **TIME**: 2 HOURS

1a. Describe five techniques for project estimating. **[15 marks]**
b. Itemize other influencing factors affecting project estimates. **[3 marks]**
c. What do you understand by estimating for supporting activities in project management? **[5½ marks]**

2a. Why is the use of risk management techniques becoming increasingly important in IS project? **[3 marks]**
b. Describe a five-stage process for project risk management **[15 marks]**
c. Describe the content of risk register. **[5½ marks]**

3a. Describe characteristics of project management. **[9 marks]**
b. Mention nine knowledge areas of project management. **[4½ marks]**
c. Mention six internal responsibilities of a project manager. [**6 marks]**
d. What are the external responsibilities of a project manager? **[4 marks]**

4a. Describe the six types of feasibility used to evaluate a project. **[12 marks]**
b. Mention reasons for project initiation. **[3 marks]**
c. Itemize seven attributes of a software project. **[3½ marks]**
d. Describe briefly approaches for building work breakdown structure. **[5 marks]**

5a. Define the following terms:
i. Software quality assurance ii. Software reliability
iii. Software configuration iv. Configuration management
v. Software availability **[7½ marks]**
b. Mention eight measurable characteristics of software quality **[4 marks]**

c. What is the relevance of software configuration management? **[2 marks]**

d. Mention four tasks associated with configuration managers based on SCMP IEEE 828-2005 standard. **[4 marks]**

e. Describe briefly four effective techniques of identifying task of work breakdown structure. **[6 marks]**

Marking Guide for MIS415

Question One

1a.

1. **Analogy method** – is the oldest and most reliable method. It depends on finding a project similar to the current one which has been undertaken in the organisation. The similarity should ideally extended to:

i. The type of business involved.
ii. The overall size of the applications.
iii. The general scope of the systems – for example, the ratio of online to batch functions.
iv. The technical methods, standards and languages used.

The major advantage of the analogy method is that it enables a broad-brush estimate for a whole project to be developed fairly quickly, perhaps during the preparation of a bid or proposal. The great danger is that there are actually fewer similarities between the two projects than initially appears to be the case. If the older project turn out to be more complicated or broader in scope, then the result might be an **overestimate** which make the bid uncompetitive. If the newer project is the more complex with new and untried techniques, then an **underestimate** might be produced, resulting in loss if the company wins the business.

[3 marks]

2. **Analysis effort method** – the general idea is to estimate the effort required to perform the analysis work for an assumed number of project functions and then derive the estimates for subsequent project stages via the use of ratios to analysis effort. As a starting point, some idea is needed of the overall range of functions which are to be provided. The next step is to make some assessment of the three key factors which will apply to the project in terms of its size, familiarity and complexity.

3. **Programming method** – the simplest way of assessing the programs is to decide if each is likely to be small, medium or large. The estimator then uses metrics from other projects or their experience to establish an average effort figure for CUT.

- For example, visual basic environment.

✓ Small program 5 days
✓ Medium program 10 days
✓ Large program 15 days

4. **Direct estimation based on project breakdown** – it is most detailed estimating technique and depends upon having a breakdown of the work to be performed. The two principal methods of breaking down the work – using a work breakdown structure or product breakdown structure. This method produces the most reliable results but, for a variety reasons, it is not always possible to use it. At the start of a project, there is probably insufficient information to enable the full set of products or tasks to be identified. The method take a great deal of time and effort which might not be available in a bid situation. Even if time is available, the costs of direct estimation may not be justified when compared through other method

5. **The Delphi technique** – the Delphi technique is based on the idea of obtaining estimates from suitably qualified and then synthesising them to produce the final estimate. Since people have differing levels of experience of estimating, and of the underlying hardware and software to be used, the approach has a number of stages:

- ✓ Each estimator is given a specification of the work – activity, task – and asked to provide their estimate for it. These are filled in anonymously.
- ✓ The estimates are then summarised anonymously and the summary is circulated to each estimator.
- ✓ Estimators reconsider their own estimates in the light of the summary and provide a revised estimate if they wish.

The above processes are repeated as many times as necessary to achieve a reasonable consensus. By keeping the estimates anonymous, personal disagreements are kept out of the process. It avoid round-table discussion which the person with loudest voice rather than the person with the best estimate, will win the day. Individual estimators can reconsider and revise their ideas in the light of other people's estimates without public loss of face.

6. **CoCoMo** – the **constructive cost model** presents formulae for calculating the effort and elapsed time needed to develop software based on an assessment of the amount of program code to be developed expressed in thousands of delivered source instructions or KDSI.

- The basic CoCoMo formula for development effort is:
  MM = 2.4(KDSI)^1.05

where MM = effort in man-months. So, if we estimate that our project will result in 10,000 delivered source instructions, we can calculate that the development effort will be:
2.4 * (10,000)^1.05 = 26.92, or about 27 man-months

- In the CoCoMo formulae, a man-month equates to 152 working hours or 19 working days, so effort figures can be expressed in man-hours, man-days or man-years.
- The elapsed time is calculated using the formula:
  TDEV = 2.5(MM)^0.33

where TDEV is total development time. For our example, the elapsed time would be calculated as:
2.5 * (26.92)^0.33 = 8.94, or about 9 months.

[3 * 5 marks]

1b.

Other factors influencing estimates

a. Use of inexperienced staff
b. Use of contract staff
c. User involvement and availability
d. User support during acceptance
e. Installation and commissioning
f. Warranty

[3 marks]

1c.

Estimating for supporting activities

It is relatively easy to identify the main tasks of the project such as conducting interviews, writing code and performing system tests, but there are scores of other activities which seem insignificant by themselves but which can amount to a lot of time over the length of the project. These includes:

1. Team leading/supervision
2. Documentation
3. Quality control
4. Quality assurance
5. Staff technical training
6. Data conversion and system migration
7. Reviewing third-party work
8. Post implementation review

[5½ marks]

Question Two

2a.

All projects are associated with one risk or the other. These risks may stem from the nature of the work for example if there is a lot of innovation involved, from the type of resources available, from the contractual relationship or from political factors which influence the project. Therefore, the need to recognise the existence of risks and prepares, in advance, method of dealing with if they occur.

[3 marks]

b.

Risk identification

The first step involved in managing risks is to discover what they are. It is clear that there are many areas in which risks could arise and it is difficult for project manager to be sure that all of the possible risks have been identified. All known risks must be highlighted. Once the risks have been identified, they need to describe clearly what each risk is all about.

[3 marks]

Risk Assessment

Once the risks are identified, it is necessary to make an **assessment** of their *impact* and *likelihood*. It is sometimes necessary to assess the impact scientifically, by calculating the likely delay as a proportion of project effort. Usually, an assessment that an impact is large, moderate or small will suffice. These could be related to the time/cost/quality criteria like this:

- Large impact: could extend project by more than 10%.
- Moderate impact: could extend project by 5-10 %.
- Small impact: could extend project by less than 5 %.

The other factor to consider is the likelihood, or probability, of the risk's materialising. The likelihood could be given a rough numerical value like this:

- High probability: greater than 30%
- Medium probability: 10-30%
- Low probability: less than 10%

We are able to compare the risks to decide which ones need the closest management attention. Obviously, the most important ones are those with a large impact and a high probability of occurrence.

[4 marks]

Risk Actions

Once the risks are identified and quantified their effects. However, this is useless unless some actions are taken to deal with the risks. In essence, there are four main responses to risk:

- **Acceptance**. It may be that there are no feasible countermeasures, or that these are more expensive than suffering risk to occur.
- **Avoidance.** This involves the things we can do to try to prevent the risks from occurring (in other words, dealing with the likelihood).
- **Mitigation**. This include the steps we can take to reduce the impact of the risks if they occur (in other words, dealing with the impact).
- **Transfer.** This involves making the impact of the risk, if it occurs, fall on someone else. Taking out household insurance, for example, does not reduce the likelihood of your house being burgled but, if it is, the impact is felt by the insurance company.

[4 marks]

Risk management planning and control

The initial identification of risks and their countermeasures is only part of risk management. As a project proceeds, the nature of risk changes:

- Some of the predicted risks materialise and have to be managed like other project issues – hopefully using mitigation actions previously identified.

- Some of the predicted risks disappear, having been overtaken by events.
- New risks appear, not anticipated at the start of the project.
- Roles and responsibilities – who will be in charge of the risk management process and the mechanism by which risks will be reviewed and control.
- A description of the products of risk management – for example, a regular risk assessment report prepared for senior management.

Risk management is therefore an on going process. There is need to be a procedure to revisit the risk register regularly and to reassess the status of each risk. On many projects, the review of risks is undertaken at regular progress meetings

[4marks]

c.

- A *reference* – each risk needs a unique identifier, perhaps keyed to the phase, task or product on which it impacts.
- A *title* and *description* of the risk
- The *current status* of the risk – for example, candidate (identified but not yet quantified), live, or closed.
- *Potential impacts* – there may be more than one of these and for each, you need to record a description and assessment of its likelihood and scale of impact.
- *Risk owner* – the person who will be responsible for carrying out the identified risk actions.
- *Actions* – the avoidance, mitigation and transfer actions that have been identified.
- *Action log* - a record of the progress made in discharging the risk actions.

[4 marks]

Question Three

3a.

1. A single person, the project manager, heads the project organization and work independently of the normal chain of command. The project organization reflects the cross-functional, goal oriented, temporary nature of the project.
2. The project manager is the person who brings together all efforts to meet project objectives.
3. Because each project requires a variety of skills and resources, project work might be performed by people from different functional areas or by outside contractors.
4. The project manager is responsible for integrating people from different functional areas or outside contractors.
5. The project manager negotiates directly with functional managers or contractors who might be responsible for the individual tasks and personnel within the project.
6. While project manager focuses on delivering a particular product or service at a certain time and cost, functional managers are responsible for the pool of workers and resources in their areas. As a result, conflict may arise between project and functional managers over people and resources allotted to a project.

7. A project might have two chains of command – one functional and one project – and people working in a project report to both a project manager and a functional manager.
8. Decision making, accountability, outcomes and rewards are shared between the project team and supporting functional units and outside contractors.
9. Although the project organization is temporary, the functional or subcontracting units from which it is formed are permanent. When the project ends, the project organization is disbanded and people return to their functional or subtracting units

[9 marks]

b.

1. Scope management
2. Time management
3. Cost management
4. Quality management
5. Human resource management
6. Communication management
7. Risk management
8. Procurement management
9. Project integration management

[4½ marks]

c.

1. Identify project tasks and build a work breakdown structure.
2. Develop the project schedule.
3. Recruit and train team members.
4. Assign team members to tasks.
5. Coordinate activities of team members and subteams.
6. Assess project risks.
7. Monitor and control project deliverables and milestones.
8. Verify the quality of project deliverables.

[6 marks]

d.

- Some of the major external responsibilities include the following:

1. Report the project's status and progress.
2. Establish good working relationships with those who identify the needed system requirements (that is, the people who will use the system).
3. Work directly with the client (the project's sponsor) and other stakeholders.
4. Identify resource needs and obtain resources.

[4 marks]

Question Four

4a.

1. Assess the risk to the project (risk management).
2. Determine the organizational and cultural feasibility.
3. Evaluate the technological feasibility.
4. Determine the schedule feasibility.
5. Assess the resource feasibility.
6. Determine the economic feasibility.

Assess the risk to the project (risk management).

Risk management - the project management area in which the team tries to identify potential trouble spots that could jeopardize the success of the project. Risk management is done throughout the life of the project. Brainstorming sessions that include key project members and stakeholders are a good way to identify risks.

[2 marks]

Determine the organizational and cultural feasibility

Each company has its own culture, and any new system must be accommodated within that culture. The analysts involved with feasibility analysis should evaluate organizational and cultural issues to identify potential risks for the new system. Such issues might include the following:

- ✓ A current low level of computer competency
- ✓ Substantial computer phobia
- ✓ A perceived loss of control by staff or management
- ✓ Potential shifting of political and organizational power due to the new system
- ✓ Fear of change of job responsibilities
- ✓ Fear of loss of employment due to increased automation
- ✓ Reversal of long-standing work procedures

[2 marks]

Evaluate the technological feasibility

The project management team needs to assess carefully the proposed technological requirements and available expertise. The solutions to technological risks include providing additional training, hiring consultants, or hiring more experienced employees. In some cases, the scope and approach of the project may need to be changed to ameliorate technological risk.

[2 marks]

Determine the schedule feasibility

The development of a project schedule always involves high risk. Every schedule requires many assumptions and estimates without adequate information. For example, the needs, and hence the scope, of the new system are not well known, the time needed to research and finalize requirements must be estimated, and the availability and capability of team members are not completely known. One objective of defining milestones during the project schedule is to permit the project manager

to assess the ongoing risk of schedule slippage. If the team begins to miss milestones, the manager can possibly implement corrective measures early. Contingency plans can be developed and carried out to reduce the risk of further slippage.
[2 marks]

Assess the resource feasibility
The project management team must also assess the availability of resources for the project. The primary resource consists of team members. Development projects require the involvement of systems analysts, system technicians, and users. Required people may not be available to the team at the necessary times. The other resources required for a successful project include adequate computer resources, physical facilities, and support staff. Generally, these resources can be made available, but the schedule can be affected by delays in the availability of these resources.
[2 marks]

Determine the economic feasibility
Economic feasibility consists of two tests:

(1) Is the anticipated value of the benefits greater than projected costs of development? and
(2) Does the organization have adequate cash flow to fund the project during the development period? A determination of the economic feasibility of the project always requires a thorough **cost/benefit analysis.**

[2 marks]
b.
1. To respond to an opportunity
2. To resolve a problem, and
3. To conform to a directive.

[3 marks]
c.
1. Having a single, definable goal or purpose and well-defined end-items or deliverables
2. Being unique
3. Being somewhat or largely unfamiliar and risky
4. Utilizing skills and talents from different professions and organizations
5. Being a temporary activity
6. Having something at stake
7. Being the process of working toward a goal

[3½ marks]
d.
1. The first approach identifies every deliverable, both intermediate and final, that must be developed. Then the WBS identifies every task that is necessary to create that

deliverable. For example, if the project is to build a house, one of the intermediate deliverables would be to install the electrical wiring. The tasks for that deliverable relate to hiring an electrical contractor, drilling holes, running wires, connecting junction boxes, connecting fixtures, and so forth.

[2 marks]

2. The second approach—the sequential timeline approach—works through the normal sequence of activities that are required for the final deliverable. For our example of building a house, the sequential timeline approach relates to tasks such as surveying the property, digging the foundation, pouring the foundation, framing the walls, and so forth

[2 marks]

Question 5

a.

i. Software quality assurance is conformance to explicitly stated functional and performance requirements, explicitly documented development standards, and implicit characteristics that are expected of all professionally developed software.

ii. Software reliability is defined as the probability of failure free operation of a computer program in a specified environment for a specified time. It can be measured, directed and estimated.
A measure of software reliability is mean time between failures where
MTBF = MTTF + MTTR
MTTF = mean time to failure
MTTR = mean time to repair

iii. Software Configuration Management encompasses the disciplines and techniques of initiating, evaluating and controlling change to software products during and after a software project.

iv. Configuration is an aggregation of hardware, software, or both, designated for configuration management and treated as a single entity in the configuration management process.

v. Software availability is the probability that a program is operating according to requirements at a given point in time.
Availability =MTTF/(MTTF + MTTR) * 100%

[1½ * 5 marks]

b.

The measurable characteristics of software quality are:

i. Correctness,
ii. Maintainability,
iii. Portability,

iv. Testability,
v. Usability,
vi. Reliability,
vii. Efficiency,
viii. Integrity,
ix. Reusability and
x. Interoperability.

[4 marks]

c. Multiple people have to work on software that is changing. More than one version of the software has to be supported. It manages evolving software systems and controls the costs involved in making changes to a system.

[2 marks]

d.

i Define configuration items
ii Define promote /release policies
iii Define activities and responsibilities
iv Set up configuration management system

[4 marks]

e.

1. **Top-down:** Identifying major activities first and then listing internal tasks
2. **Bottom-up:** Listing all the tasks you can think of and organizing them later
3. **Template:** Using a standard template of tasks for projects that are fairly standard
4. **Analogy:** Finding a similar, or analogous, project that is finished and copying its tasks

[6 marks]